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SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
Bulletin 65

DENDROID GRAPTOLITES OF THE NIAGARAN DOLOMITES AT HAMILTON, ONTARIO

Compiled by

RAY S. BASSLER

Curator, Division of Invertebrate Paleontology
U. S. National Museum

WASHINGTON
GOVERNMENT PRINTING OFFICE
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BULLETIN OF THE UNITED STATES NATIONAL MUSEUM.

Issued July 10, 1909.

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This work forms No. 65 of the Bulletin series.

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RICHARD RATHBUN,
Assistant Secretary, Smithsonian Institution,
In Charge of the United States National Museum.

WASHINGTON, U. S. A., *June 20, 1909.*

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DENDROID GRAPTOLITES OF THE NIAGARAN DOLOMITES AT HAMILTON, ONTARIO.

Compiled by Ray S. Bassler,
Curator, Division of Invertebrate Paleontology, U. S. National Museum.

INTRODUCTION.

The large collection of graptolites which has been accumulating in the U. S. National Museum for many years, mainly through transfer from the U. S. Geological Survey, has recently been classified and so arranged that all of the specimens are now available for study. Fifteen years ago, Dr. R. R. Gurley, then connected with the U. S. Geological Survey, undertook a monographic study of the graptolites of the world with specimens now constituting the greater portion of the Museum's present collection as the basis for his work. Doctor Gurley accumulated a mass of manuscript relating chiefly to the bibliography of these organisms, but his resignation from the survey brought the work to an end. Nothing further was done with either the specimens or manuscript until 1905, when an arrangement was made with the director of the New York State Museum, whereby Dr. Rudolph Ruedemann, assistant state paleontologist, should study Doctor Gurley's unpublished types and use as much as possible of the manuscript in connection with his studies on the graptolite faunas of New York. In his preface to Part 2 of the Graptolites of New York,[a] Doctor Ruedemann writes the following:

> Our request [for the loan of Gurley's types] was most liberally granted by the authorities of the U. S. Geological Survey and of the National Museum, but with the specimens there was delivered to us the voluminous unfinished manuscript of Gurley's monograph of the graptolites with the understanding that we should use as much as possible of the same, and thus assure to Doctor Gurley's long labors the credit to which they are entitled. The author has gladly availed himself of Gurley's work, which even in its fragmentary form bears witness not only of the admirable patience and enthusiasm of its author, but also of his keen power of observation.
>
> In justice to both Doctor Gurley and myself a full statement of what this voluminous manuscript contains and what has been used for this memoir should be given in this place.

[a] New York State Museum, Memoir 11, 1908.

The greater part of the manuscript consists of copies of the descriptions, and translations of those in other than the English language, of all foreign species of graptolites together with a full bibliography of all species described up to 1896. It is obvious that it was the author's intention to produce a monograph of all the graptolites of the world.

Another part of the manuscript contains the history and synonymy of the American species. In this work Doctor Gurley had evidently made special efforts to trace the history of many of the cryptic names of the earlier geologists, as those of the graptolites mentioned in the reports of the first geological survey of New York by Emmons and others. These notes are fairly complete; they have been used here as far as the scope of our work allowed, and due credit given the author.

In the description of the North American graptolites Gurley had not proceeded beyond the Dendroidea and a part of the Graptoloidea of the Lower Champlainic. The former consist in the large majority of the Niagaran forms from Hamilton, Canada, which lie without our field, and the descriptions of the latter faunas are entirely based upon Canadian material.

In another paragraph Doctor Ruedemann has the following to say regarding Doctor Gurley's monograph:

On the whole, it may be fairly said that Doctor Gurley has printed in his preliminary publication in the Journal of Geology all that was new or especially worthy of publication, namely, the descriptions of all new species—with the exception of a few Dendroidea—and his observations on the morphology of certain hitherto incompletely known species (e. g., *Clathrograptus geinitzianus*). Still there was enough left in the manuscript to make it a welcome help to the writer in many ways. Its extensive bibliography of the graptolites, which is practically complete to 1896, might be published as a separate bulletin, as also eventually the Dendroidea. This done, full justice, I believe, would have been rendered to Doctor Gurley's assiduous labors on the graptolites.

From time to time attempts have been made to arrange the Gurley manuscript so that portions of it at least could be prepared for publication, but it finally became apparent that the dendroid forms from Hamilton, Ontario, were all that could be said to be available for this purpose, without a complete restudy and redescription of the forms. At the request of the secretary of the Smithsonian Institution I have arranged the present article, using Doctor Gurley's descriptions and drawings as a basis, but in order to illustrate the fauna properly additional photographs were necessary. As these are my own work, it would be unfair to attribute any mistakes in them to Doctor Gurley, and they have, therefore, been designated accordingly on the descriptions of the plates. For the same reason, it may be noted that the identification and arrangement of the drawings, the descriptions of the text figures and plates, and other matters, exclusive of the descriptions of species and notes accredited to Doctor Gurley, have been introduced by me.

While the present work has been in part that of compilation, yet it is only fair to say that in order to do the subject justice, a restudy

of the various collections of Hamilton, Ontario, graptolites was necessary. This restudy resulted in the suppression of a number of Gurley's manuscript names and descriptions, which in themselves gave evidence that they did not represent the author's final judgment.

But few of the specimens in the national collection were labeled so that they could be assigned to their proper species without further study. Fortunately, in many instances the illustrated specimens were numbered and mentioned by number in the manuscript. Specimens in the collections of the New York State Museum and the Walker Museum of Chicago University, kindly loaned by the authorities of these respective institutions, proved to be better supplied with labels, and the study of them helped greatly in the identification of the species.

A few words in connection with the preparation of the accompanying illustrations may be of some interest. Doctor Gurley's drawings were prepared by first inking in the graptolite as seen on ordinary blueprint photographs of the specimens, and then bleaching out the background. This method, although satisfactory in many cases, did not give good results with poorly defined specimens, so in the additional illustrations which were made the following method of procedure was used: The objects were first treated to a thin coat of French retouching varnish, which brought out the details of even the poorest material fairly well. Specimens so coated are in excellent shape for study, but on account of the reflection of light from the slightly polished surfaces, do not lend themselves well to photography. This difficulty was overcome by photographing the specimen immersed in water.

The wonderful fauna of dendroid graptolites at Hamilton, Ontario, has been collected with untiring enthusiasm by Col. C. C. Grant, to whom science is indebted for the discovery of many new species. Colonel Grant has published interesting popular accounts of the geologic features at Hamilton in the Journal and Proceedings of the Hamilton Association, and has likewise figured, without description, some of the more interesting graptolites. Up to the present time the description of these forms has been mainly from the pen of Prof. J. W. Spencer, whose articles upon the subject are noted in the bibliography of the species beyond. More recently Doctor Ruedemann has described the Niagaran forms occurring in New York.

In the present article I have endeavored to carry out Doctor Gurley's plan of publishing complete descriptions of these dendroid graptolites. For this reason the original descriptions of Spencer and others are inserted whenever they have been thought to add to the completeness of the work. Likewise all of the species have been illustrated, either by copies of the original figures or by additional drawings and photographs, and in some cases by both.

The destruction by fire of the museum building at the University of Missouri some years ago resulted in the loss of all of Spencer's original types. No additional specimens of some of his species have come to hand in later collections, so that such species must rest on their descriptions and figures alone. However, it must be stated that all specimens quoted in the descriptions, other than Spencer's figured types, are still extant.

Professor Spencer has published a detailed section of the rocks at Hamilton, which is repeated here for ready reference of the graptolites to their horizon.

Geologic section at Hamilton, Ontario.[a]

This section was measured along the brow of the escarpment at the city of Hamilton, between the ravine at the head of James street and the "Jolly Cut" road, about half a mile to the eastward.

	Thickness in feet.	
Niagara Formation.		
Bed No. 12. Thin gray dolomites with an abundance of cherty nodules. This bed is known as the "Chert bed," and forms the brow of the escarpment at Hamilton and eastward, being 388 feet above lake at head of James street. At head of Queen street this series is 19 feet thick	12.0	
Bed Nos. 11 and 10. Argillaceous dolomites, with shaly partings—upper portion known as the "Blue Building beds." Beds 0.5–1 foot thick	15.5	
Bed No. 9. Dark hard dolomitic shales and dolomites weathering to gray—and lower beds most shaly	10.5	
Bed No. 8. Thick bed gray crystalline dolomite (nearly pure)	4.5	
Bed No. 7. Argillo-arenaceous dolomite in beds from 1–1.5 feet thick	8.8	
		51.3
Clinton Formation.		
Bed No. 6*b*. Earthly dolomite, with shaly partings	8.0	
Bed No. 6*a*. Clinton shales, all dolomitic, with thin beds of harder rock, some of which are arenaceous, and others to a thickness of about 7 feet are areno-ferruginous. The upper 9 feet may be considered as passage beds	76.9	
Bed No. 5. Passage beds of argillaceous dolomites. (Top projecting portion is glaciated, and is 254 feet above lake)	8.8	
		93.7
Medina Formation.		
Bed Nos. 4 and 3. Coarse, gray sandstone—"Gray Band." This bed varies in thickness	6.5	
Bed Nos. 2 and 1. Medina variegated red and green shales. Thickness from calculation of Dundas artesian well	538.5	
		545.0
Total thickness		690.0

[a] J. W. Spencer, Canadian Naturalist, X, 1883, p. 136.

All of the species and varieties noted in the following pages occur in the Niagaran limestone at Hamilton, the especial portion in the section being indicated under the descriptions. These limestones seem to belong entirely to the Lockport division of the Niagaran, although it is possible that beds 7 to 9 of the section represent the Rochester shale of western New York. This latter view is suggested by the fact that of the six species common to the Rochester shales and Lockport limestone, namely, *Dictyonema retiforme*, *D. polymorphum*, *D. subretiforme*, *Cyclograptus rotadentatus*, *Inocaulis plumulosus*, and *Acanthograptus walkeri*, two or three are limited to the shaly strata at the base of the Niagaran limestone, while the exact position of at least two more is uncertain. The essential unity believed by Ruedemann to exist between the graptolite faunas of the Rochester shale and the Niagaran limestone at Hamilton is therefore more doubtful.

DESCRIPTIONS OF GENERA AND SPECIES.[a]

Order DENDROIDEA Nicholson.

Family DENDROGRAPTIDÆ Roemer.

Genus DENDROGRAPTUS Hall.

Dendrograptus Hall, Rep. Progr. Geol. Surv. Canada for 1857, 1858, p. 143; Geol. Surv. Wisconsin, I, 1862, p. 21; Geol. Surv. Canada, Decade 2, 1865, pp. 126, 127; 20th Rept. New York State Cab. Nat. Hist., 1868, p. 218, (rev. ed., 1868 [1870], p. 252).—Carruthers, Geol. Mag., V, 1868, pp. 73, 130.—Zittel, Handbuch d. Pal., I, 1879, p. 289.—Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 562, 566; Bull. Mus. Univ. State Missouri, 1, 1884, p. 16.—Miller, North Amer. Geol. and Pal., 1889, p. 184.—James, Journ. Cincinnati Soc. Nat. Hist., XIV, Pt. 2, 1892, p. 151.—Počta, Syst. Sil. Centre Boheme, VIII, Pt. 1, 1894, p. 165.—Roemer and Frech, Leth. geog., I Theil, Leith. Pal., I, 3 Lief., 1897, p. 577.—Elles and Wood, Mon. Brit. Graptolites, Pal. Soc., 1903, p. xli.—Ruedemann, New York State Mus., Mem. 7, 1904, p. 578.

Dendrograpsus Nicholson, Quart. Journ. Geol. Soc. London, XXIV, 1868, p. 142; Mon. Brit. Graptolitidæ, 1872, p. 127.

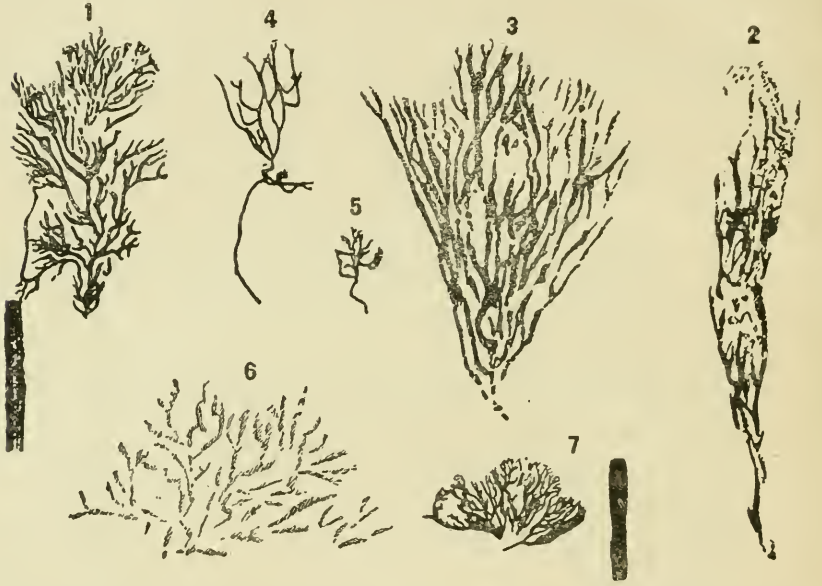
According to Ruedemann:

The genus *Dendrograptus* was created for forms with a strong main stem and a broad, spreading, shrub-like, variously ramifying frond. The thecæ are described as quite distinct and angular in some (the type-species of the genus, *D. hallianus* Prout), of obscure forms in others, while in still others they are shown only as round or elliptical pits or postules.

Genotype.—Graptolithus hallianus Prout. Upper Cambrian, Osceola Mills, Wisconsin. The species is also known from several localities in the Upper Cambrian of Tennessee and Alabama.

[a] Unless otherwise stated, all of the text figures were made either by Doctor Gurley or under his supervision, and are of natural size.

Nine species of *Dendrograptus* are here noted, two of which are new. This is not the complete representation of the genus at Hamilton, Ontario, since Doctor Gurley's manuscript includes short descriptions, unaccompanied by illustrations, of three additional species, each of which is represented by a single specimen said to be in the New York state collections. As these specimens are inaccessible at the present time the descriptions are omitted. To complete the notes on this fauna, however, it may be added that one of these species is a very slender, rigid little form, with sharp, V-shaped bifurcations; the second has very thick stems and branches, the latter upright, close



FIGS. 1–7.—1, DENDROGRAPTUS DAWSONI SPENCER. A FROND NATURAL SIZE AND A BRANCH ENLARGED; 2, D. DUBIUS MILLER; 3, D. RAMOSUS SPENCER. A FROND WITH A BRANCH ENLARGED; 4, D. PRAEGRACILIS SPENCER; 5, D. SPINOSUS SPENCER; 6, D.? PROBLEMATICUS SPENCER; 7, D. FRONDOSUS SPENCER. A FROND NATURAL SIZE AND BRANCH ENLARGED. (COPIED FROM SPENCER.)

together, and parallel, while the branches of the third are narrow at their origin, but widen uniformly to their bifurcations or free ends.

DENDROGRAPTUS DAWSONI Spencer.

Text figure 1.

Dendrograptus dawsoni SPENCER, Can. Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 568, pl. 1, fig. 5; Bull. Mus. Univ. State Missouri, No. 1, 1884, pp. 14, 18, pl. 1, fig. 5.—MILLER, North Amer. Geol. and Pal., 1889, p. 184.—GURLEY, Journ. Geol., IV, 1896, pp. 94, 308.

Doctor Spencer's description is as follows:

Frond erect and treelike. Stipe short, but extending upward and dividing into two or three principal branches, each bifurcating twice or thrice, and at the

same time giving off several slightly diverging branchlets at irregular distances on both sides. The lower part of the stipe or trunk also gives off several branchlets. The outline of the frond is cleft or divided into somewhat rounded lobes, with branches more or less upright. The corneous surface is strongly marked with striations. The cellular openings are oval on one side of the axis, as represented in figure 5*a*. However, there are undulations or swellings on some of the surfaces.

This little fossil is one of the most beautiful of the Graptolite family found in the Niagara formation. It is 4 cm. high and with a breadth of 2 cm., while the branches are less than half a millimeter thick and nearly double that distance apart. There is a strong resemblance to *D. fruticosus* of the Quebec group. Only one good specimen is in my possession.

Formation and locality.—This specimen was obtained by Colonel Grant in the dolomitic shales, below the chert bed of the Niagara formation, at the "Jolly-cut road," Hamilton, Ontario.

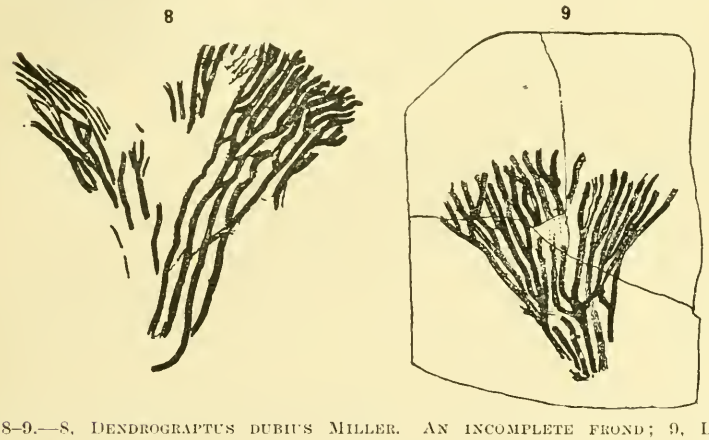
No additional specimens of this species occur in the later collections.

DENDROGRAPTUS DUBIUS Miller.

Text figures 2, 8.

Dendrograptus simplex Spencer, Can. Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 567, 568, pl. 1, fig. 4; Bull. Mus. Univ. State Missouri, No. 1, 1884, pp. 14, 17, 18, pl. 1, fig. 4 (name preoccupied).

Dendrograptus dubius Miller, North Amer. Geol. and Pal., 1889, p. 184.—Gurley, Journ. Geol., IV, 1898, pp. 94, 308.



Figs. 8–9.—8, Dendrograptus dubius Miller. An incomplete frond; 9, Dendrograptus ramosus Spencer. A frond branching uniformly. (See also Pl. 1, fig. 3.)

Doctor Spencer originally described this species under the name of *Dendrograptus simplex*, a name preoccupied and replaced by Miller with *D. dubius*. The original description of *D. simplex* is as follows:

Frond erect, with strong branches originating from a lengthy flexuous stipe, and diverging slightly above. The branches bifurcate only once or twice and are closely crowded together. Transverse bars are apparent in one or two places. The texture is corneous, with surface striated. On one side there are oval depressions marking the cell orifices; these are nearly a millimeter in length, and are situated about double that distance apart. Rudimentary branches are given off on each side of the stipe.

Of this species I have only one specimen. It is 5 cm. high, besides the single basal stipe, which is nearly 2 cm. long. The branches diverge from their initial points on the stipe until the summit is rather more than a centimeter broad, although there are six or seven branchlets present, each having the breadth of a millimeter and situated about the same distance apart.

Formation and locality.—This specimen was found in the Niagara dolomite at the "Jolly-cut road," Hamilton, Ontario.

A single specimen from the Niagara dolomite, Hamilton, Ontario, loaned by the Hamilton Museum (text fig. 8), agrees in all essential points with Spencer's description, and apparently represents this species. A drawing of this specimen was prepared by Doctor Gurley, whose manuscript also contains the following notes upon the species:

Evidently Spencer's figure represents a crushed or weathered specimen, so that such deviations from it as occur here are merely such as would be expected in better material. The branches mostly measure 0.8–1 mm. and are separated by about their own width or a little more. The branches are more numerous near the top, resulting in being more bushy in this region. This species is distinguished from the other species at this horizon by the stoutness of its branches and the size of the polypary.

DENDROGRAPTUS FRONDOSUS Spencer.

Text figure 7.

Dendrograptus frondosus Spencer, Can. Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 568, 569, pl. 1, fig. 6; Bull. Mus. Univ. State Missouri, 1, 1884, pp. 14, 18, 19, pl. 1, fig 6.—Miller, North Amer. Geol. and Pal., 1889, p. 184.—Gurley, Journ. Geol. IV, 1896, pp. 94, 308.

Several fragmentary specimens from the Niagara dolomites, in the collection of the U. S. National Museum, seem to belong to this species. They show no features in addition to those pointed out in the original description, which is as follows:

The frond is low and broadly flabellate, originating from a short slender stipe, which divides twice or thrice, after which the divisions extend to the summit of the several lobes, and send off branches at irregular distances on both sides. The branches give rise to lateral branchlets rather than bifurcations. The branches are short and slender, not exceeding one-third of a millimeter in thickness. The surface is striated; the cellular openings are minute and oval, but usually indistinct. Figure 6*a* represents an enlarged branch.

This graceful little frond is less than 2 cm. broad, and $1\frac{1}{4}$ cm. high.

Formation and locality.—It occurs in the Niagara dolomite at Hamilton, Ontario.

DENDROGRAPTUS RAMOSUS Spencer.

Text figures 3, 9. Plate 1, figure 3.

Dendrograptus ramosus Spencer, Can. Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 567, pl. 1, fig. 3; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 17, pl. 1, fig. 3.—Miller, North Amer. Geol. and Pal., 1889, p. 185.—Gurley, Journ. Geol., IV, 1896, pp. 95, 308.

Doctor Spencer's description is as follows:

Frond moderately flabelliform. The base of the frond arises from a single stipe, and from near its summit most of the branches originate and moderately diverge above, with few bifurcations. The texture is corneous, with the surface strongly striated. The cellules are arranged along one of the margins of the branches, and have angular openings, processes, or cell denticles, marking these openings as in figure 3*a*, which is a branch enlarged.

The largest frond is 4 cm. high, exclusive of the basal stipe, of which the length of a centimeter is preserved. It expands above in straight radiating branches until the summit is rather more than 3 cm. across. The not-very-numerous branches are comparatively stout, being about a millimeter broad. The branches occasionally touch or overlap, but this arises from the manner in which they were compressed in the rock. This species is easily distinguished from any other of the group that is obtained at Hamilton.

Formation and locality.—This fossil is found in the more shaly dolomites below the "Chert beds" of the Niagara formation, at the "Jolly-cut road," Hamilton, Ontario.

This species is represented by two specimens in the Spencer collection, one of which has been photographed and figured by Doctor Gurley. (Text fig. 9 and Pl. 1, fig. 3.) According to this figure, the width of the branches is usually 0.8 mm., not infrequently reaching 1 mm.; a few as narrow as 0.6 mm. The branches are set about 17 to 20 in 25 mm. of width.

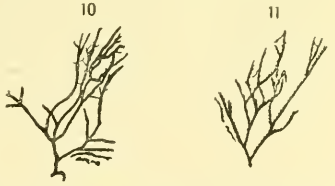
DENDROGRAPTUS PRAEGRACILIS Spencer.

Text figures 4, 10. Plate 2, figure 3.

Dendrograptus praegracilis SPENCER, Can. Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 569, pl. 1, fig. 7; Bull. Mus. Univ. State Missouri, 1, 1884, pp. 14, 19, pl. 1, fig. 7.—MILLER, North Amer. Geol. and Pal., 1889, p. 185.—GURLEY, Journ. Geol., IV, 1896, pp. 95, 308.

The original description is as follows:

Frond diffuse. The branches, few in number (three or four), originating from a long slender stipe, with each sending off smaller, very slender branchlets. Surface striated, and celluliferous on one side. Branches about a quarter of a millimeter broad and diverging considerably. The umbelliferous summit is about as broad as high (measuring 1½ cm., besides the long stipe).



FIGS. 10–11.—10, DENDROGRAPTUS PRAEGRACILIS SPENCER (SEE ALSO PL. 2, FIG. 3); 11, DENDROGRAPTUS PHAINOTHECA, NEW SPECIES. VIEW OF THE TYPE-SPECIMEN. (SEE ALSO PL. 2, FIG. 2.)

The mode of branching and general appearance of this fossil closely resembles *D. gracilis* of the Quebec group, only it is much smaller.

Formation and locality.—It occurs in the Niagara dolomite at Hamilton, Ontario.

A single specimen (text fig. 10, and Pl. 2, fig. 3), from the Niagara cherty dolomite at Hamilton, Ontario, occurs in the U. S. National

Museum collection, but it presents no features not already given in the above description.

Plesiotype.—Cat. No. 55293, U.S.N.M.

DENDROGRAPTUS SPINOSUS Spencer.

Text figure 5.

Dendrograptus spinosus SPENCER, Can. Nat., X, 1882, p. 165, *nomen nudum;* Trans Acad. Sci. St. Louis, IV, 1884, pp 564, 569, pl. 1, fig. 8; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 19, pl. 1, fig. 8.—MILLER, North Amer. Geol. and Pal., 1889, p. 185.—GURLEY, Journ. Geol., IV, 1896, pp. 95, 308.

The original description is as follows:

Frond small and shrublike, with long flexous stipe extending to the summit, and giving off branches, usually, alternate and at unequal distances, and diverging from each other at considerable angles. From both stipe and branches there are numerous spinelike branchlets, which sometimes have dichotomous terminations. The surface is striated, but the cellular structure is not preserved. The branches vary from one-third to one-half of a millimeter (in different specimens) in thickness, with somewhat greater distance between. The frond is usually twice as long as wide, and varies from 1½ to 2 cm. high.

Formation and locality.—This graceful little fossil is found in the cherty beds of the Niagara dolomite, at the "Jolly-cut road," at Hamilton, Ontario.

Doctor Gurley based the following description upon a specimen in the Spencer collection:

Portion of polypary seen about 15 by 10 mm., consisting of branches which measure 0.25–0.3 mm. None were seen as large as 0.5 mm. (as reported by Spencer). In their course they zigzag slightly, the spines proceeding from the convex angle of each bend. The stems seem to be somewhat wider at each angle, to contract above, and then again gradually widen up to the next angle, thus seeming as though formed of a series of similarly oriental cones; but the material is not perfectly satisfactory on this point. Division taking place irregularly, either by oblique lateral branching, or by dichotomy, not regularly unilateral, regularly bilateral, or regularly alternate. Thecæ invisible.

DENDROGRAPTUS ? PROBLEMATICUS (Spencer).

Text figure 6. Plate 1, figures 1, 2.

Inocaulis ? problematica SPENCER, Can. Nat., VIII, 1878, pp. 458, 461; X, 1882, p. 165; Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 586, pl. 5, fig. 3; Bull. Univ. Missouri, I, 1884, pp. 14, 36, pl. 5, fig. 3.—MILLER, North Amer. Geol. and Pal., 1889, p. 194.—GURLEY, Journ. Geol., IV, 1896, pp. 99, 309.

Doctor Spencer's original description is as follows:

Plantlike, with numerous slender bifurcating branches, radiating more or less from a common center, and resembling the branches of rootlets; texture corneous with irregular corrugations.

This species is of common occurrence, and is not easily mistaken for any other. The texture is not well preseved, appearing often as mere stains of dark

color on the surface of the stone. Its relations are somewhat doubtful, but it is easily distinguished from all the other species of the family by its rootlike character and slender branches (one-fortieth of an inch) often overlapping each other in an irregular manner. It occurs abundantly in the Niagara limestones of Hamilton, Ontario.

In his description published in 1884, the following additional notes are given:

Fronds aggregated, resembling branching rootlets * * *. The height of the individual frond does not appear to have been more than 2 or 3 cm., with comparatively few branches which are about three-fourths of a millimeter broad. Yet the individuals appear to have grown in bunches or groups, and one specimen indicates a large number of fronds originating from a common rootstock, whose branches, though only three centimeters high, cover 7 or 8 cm. in breadth.

* * * More commonly the fossil consists of an irregular mass of small branches lying together and occupying space on the stone not greater than 9 or 10 square cm.

Dr. Gurley's description and notes are as follows:

The specimens I have seen may be characterized as follows: Appearance of polypary as a whole, straggling and lax in the extreme, usually without any evident plan, consisting of numerous very flexuous, undulate or more or less undulate zigzag branches, which measure about 0.7–0.8 mm. in width, bifurcating at intervals, the resulting branchlets becoming subparallel and usually about 3 or 4 mm. apart. Thecæ nowhere definitely outlined. Obscure indications of what may have been thecæ are not wanting.

Perhaps the most characteristic single feature of this species is the irregular, straggling, diffuse arrangement of the branches. In part this is owing to their frequently over or under crossing one another. In one specimen (Pl. 1, fig. 1) the branches seem to be connected with, or arise from, a discoidal body, and I believe such origin to take place, though the specimen is not well enough preserved to place the matter beyond the possibility of doubt.

Horizon and locality.—Niagara dolomite and chert, Hamilton, Ontario.

Spencer notes the species as very common in the dolomite. This formation was not being quarried when the present collection was obtained. Hence my specimens, nine in number, are all from the chert. It is worthy of note that on five of these, *D. problematicus* is growing on *Rhinopora verrucosa*, and that it in one case acquires a pseudo-structure, a serration of the margin from puncture by the *Rhinopora* cells.

Whether this is a graptolite or not is somewhat uncertain. In some places marginal indentations are visible which greatly resemble those corresponding to thecæ in other graptolites, but in no case are these unequivocal. Undoubtedly the species is not an *Inocaulis*. Among graptolites the mode of branching most nearly corresponds to that in *Dendrograptus*, and a provisional reference is made to that genus.

Plesiotypes.—Cat. No. 55294, U.S.N.M.; collection of Walker Museum, University of Chicago, No. 13510.

DENDROGRAPTUS PHAINOTHECA Gurley, new species.

Text figure 11. Plate 2, figure 2.

The following description of this species is by Doctor Gurley:

Polypary incomplete proximally, consisting only of several branches and branchlets. The two branches include an angle of about 70°. They are 0.5

mm. wide to the tips of the thecæ. It is probable that the latter are always situated on the side symmetrical with reference to the bisector of the angle included between the branches, occurring on the side toward it. They are straight, cylindrical, inclined about 25° to the branch, with the apertural margin straight and perpendicular to the branch; they are set about 45 in 25 mm.

Horizon and locality.—This species is represented by a single specimen from the Niagara glaciated chert, at Hamilton, Ontario.

Holotype.—Cat. No. 55295, U.S.N.M.

DENDROGRAPTUS ONTARIOENSIS Bassler, new species.

Plate 1, figure 4.

Although this form was distinguished by Doctor Gurley, who attached the label "*Dendrograptus ontariensis*, type" to the specimen here figured, neither description nor figure could be found among his manuscript pages.

FIG. 12.—DENDROGRAPTUS ONTARIOENSIS, NEW SPECIES. VIEW OF THE MOST COMPLETE SPECIMEN. (SEE ALSO PL. 1, FIG. 4.) (BY R. S. BASSLER.)

Dendrograptus ontarioensis is evidently closely related to *D. praegracilis* Spencer, from which, however, it may be distinguished by its more regular, erect growth, and by its dichotomously dividing, rigid branches. Comparison of the figures of these respective species will show other differences, but it is believed that those mentioned will suffice for the recognition of this new form.

Horizon and locality.—This species is based upon a single rather complete specimen in the collection of the Chicago University, from the Niagaran dolomites at Hamilton, Ontario. Several fragmentary specimens in the collection of the U. S. National Museum agree with the type in all essential respects.

Holotype.—No. 13506, Walker Museum, University of Chicago.

Genus CALLOGRAPTUS Hall.

Callograptus HALL, Geol. Surv. Canada, Decade 2, 1865, p. 133; 20th Rep. New York State Cab. Hist., 1868, p. 218 (rev. ed., 1868 [1870], p. 252).—HOPKINSON, Ann. and Mag. Nat. Hist. (4), X, 1872, p. 233.—SPENCER, Can. Nat., VIII, 1878, pp. 458–462.—ZITTEL, Handbuch d. Pal., I, 1879, p. 289.—SPENCER, Can Nat., X, 1882, p. 165; Trans. Acad. Sci. St. Louis, IV, 1884, pp. 562, 570; Bull. Mus. Univ. State Missouri, I, 1884, p. 20.—MILLER, North Amer. Geol. and Pal., 1889, p. 175.—POCTA, Syst. Sil. Centre Boheme, VIII, Pt. 1, 1894, p. 179.—MATTHEW, Trans. New York Acad. Sci., XIV, 1895, p. 271, pl. 48, fig. 5.—GURLEY, Journ. Geol. IV, 1896, pp. 93, 308.—ROEMER and FRECH, Leth. geog., I. Theil, Leth. Pal., I, 3 Lief., 1897, p. 576.—RUEDEMANN, New York State Mus., Mem. 7, 1904, p. 583.

Callograpsus NICHOLSON, Mon. Brit. Graptolitidæ, 1872, p. 128.

Gurley's manuscript contains quotations from many of the papers cited above, but no original notes are included. The following quo-

tation from Ruedemann's discussion of the genus[a] will suffice for its recognition.

Hall based his genus mainly on its mode of branching and the resulting aspect of the rhabdosome; stating that it has "numerous slender bifurcating branches proceeding from a strong stem or axis," and that in its aspect it is intermediate between *Dictyonema* and some forms of *Dendrograptus;* that the branches are sometimes distantly and irregularly united by transverse dissepiments, but that the frond has not the regular reticulate structure of *Dictyonema* and differs from *Dendrograptus* in the mode of branching and the form of the thecæ.

Genotype.—Callograptus elegans Hall. Tetragraptus zone of Quebec group, Gros Maule, Canada.

CALLOGRAPTUS MULTICAULIS Spencer.

Text figure 14.

Callograptus (Dendrograptus) multicaulis SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum.*

Callograptus multicaulis SPENCER, Trans. Acad. Sci. St. Louis, IV, 1884, p. 572, pl. 1, fig. 11; Bull. Mus. Univ. State Missouri, I, 1884, p. 22, pl. 1, fig. 11.—GURLEY, Journ. Geol., IV, 1896, pp. 93, 308.

The original description is as follows:

Frond flabellate, possibly funnel-shaped in its growing state; branches, with two or three bifurcations, strong and somewhat numerous. Surfaces deeply striated longitudinally. The branches radiate from a common radicle until they occupy three-fourths of a circle; but whether they extended all around, and the frond grew in a funnel shape, can not be determined, as the lower branchlets are crushed and obscured. This beautiful little fossil has about a dozen principal branches well preserved, and these are about half a millimeter broad, with rather greater space between. The length of each branch is slightly over a centimeter, and the breadth of the frond about double that measurement. Cells are not known.

Formation and locality.—This graceful fossil was obtained from a more shaly bed of dolomite below the "chert bed" in the Niagara formation, at the "Jolly-cut road," Hamilton, Ontario.

No additional specimens of this species have been noted in the various collections studied.

CALLOGRAPTUS NIAGARENSIS Spencer.

Text figure 15.

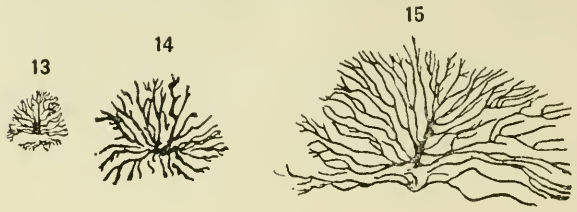
Callograptus niagarensis SPENCER, Canadian Nat., VIII, 1878, pp. 458, 463; Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 571, pl. 1, fig. 9; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 21, pl. 1, fig. 9.—MILLER, North Amer. Geol. and Pal., 1889, p. 175, fig. 141.—GURLEY, Journ. Geol., IV, 1896, pp. 93, 308.

Doctor Spencer's original description is as follows:

Frond flabellate; the slender bifurcating branches more or less parallel, with occasional transverse filaments. The form is nearly semicircular with the

[a] New York State Museum, Memoir 7, 1904, p. 583.

branches radiating from a common axis. In texture it is corneous, and the surface of the numerous flattened branches is marked with striations, appearing like oval impressions, while on the under side there are minute pits indicating the apertures of the cells, as many as twenty pits being visible in one-fourth of an inch. The fronds are usually less than 2 inches in breadth, and resemble the outline of a bush, where the branches principally originate from the root.



FIGS. 13–15.—13, CALLOGRAPTUS MINUTUS SPENCER; 14, C. MULTICAULIS SPENCER; 15, C. NIAGARENSIS SPENCER. (AFTER SPENCER.)

This species is easily distinguished from *Dictyonema* by the bushlike form and more slender branches, together with an almost entire absence of dissepiments and cell markings. In the better preserved specimens the cells readily distinguish it from *Dendrograpsus*, as also the more numerous and more parallel branches. The branches are broader, more drooping, and further separated than in the species of this genus found in the Quebec group.

Formation and locality.—This species occurs in the Niagara dolomites and shales at Hamilton, Ontario.

Gurley notes the following concerning the species, which is known only from the type, now destroyed:

The description of 1884 contains several statements requiring separate notice. The pits indicating the thecal apertures are stated to be "as many as 12 in a centimeter," a number amounting to 30 in an inch (25 mm.), as contrasted with 80. The longer diameter of the aperture is about 0.5 mm.

The frond does not usually exceed 4 cm. in breadth, being broader than high. The branches are a little less than 0.5 mm. broad, with spaces between them sometimes exceeding 1 mm.

CALLOGRAPTUS MINUTUS Spencer.

Text figure 13.

Callograptus minutus SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 572, pl. 1, fig. 12; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 22, pl. 1, fig. 12.—GURLEY, Journ. Geol., IV, 1896, pp. 93, 308.

The original description is as follows:

Frond orbicular. Branches, with one or two bifurcations, regularly diverging from the initial point like the venations of a palm leaf; they are all free. The surfaces are striated. The branches do not exceed one-fifth of a millimeter in breadth and are about half a millimeter apart. The whole height of the frond is a centimeter and the greatest breadth somewhat less.

Formation and locality.—This species occurs in the Niagara dolomite at Hamilton, Ontario.

No additional typical forms of this species have been found. Four specimens, three of which are fragmentary, furnish the basis for the description of the following variety.

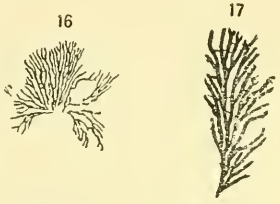
CALLOGRAPTUS MINUTUS ALTUS Gurley, new variety.

Text figure 16.

Doctor Gurley's description and notes are as follows:

Polypary as compressed (originally?), somewhat semicircular, consisting of branches about 0.2 mm. in width, bifurcating 2 to 4 times in their course toward the periphery, set about 45–50 in 25 mm. of width. Thecæ invisible. Dissepiments very slender, apparently not numerous (too few visible to measure distances).

This form seems nearly allied to Spencer's *C. minutus*, but has a larger polypary (16 mm. high). Further, while agreeing fairly well with his description of *C. minutus*, it is not so easy to approximate it absolutely to his figure. Still it is possible that with more material this variety may be surpressed.



FIGS. 16, 17.—16, CALLOGRAPTUS MINUTUS ALTUS, NEW VARIETY. VIEW OF THE HOLOTYPE; 17, C. STRICTUS, NEW SPECIES. (SEE ALSO PL. 3, FIG. 3.)

Horizon and locality.—The variety is based on two specimens (including the figured type) in the Spencer collection, from the Niagara chert, Hamilton, Ontario, and two additional specimens in the U. S. National Museum collections.

Cotypes.—Cat. No. 55311, U.S.N.M.

CALLOGRAPTUS STRICTUS Gurley, new species.

Text figure 17. Plate 3, figure 3.

This new species is based upon a single, well-preserved specimen in the collection of the University of Chicago. Doctor Gurley's description is as follows:

Branches straight or very slightly flexuous, 0.4–0.6 mm. wide, bifurcating at frequent intervals (1 to 4 mm.); longitudinally striated by chitinous threads; set 20–25 in 25 mm. Thecæ present, flattened against the branches, but obscure; apparently about 35–40 in 25 mm. Dissepiments few (at least few are preserved) and remote.

Horizon and locality.—Niagaran (Blue Building beds of section), Hamilton, Ontario.

Holotype.—Walker Museum, University of Chicago, No. 13513.

Genus PTILOGRAPTUS Hall.

Ptilograptus Hall., Geol. Surv. Canada, Decade 2, 1865, p. 139; 20th Rep. New York State Cab. Hist., 1868, p. 218 (rev. ed., 1868 [1870], p. 252).—Zittel, Handbuch d. Pal., I, 1879, p. 289.—Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 563, 591; Bull. Mus. Univ. State Missouri, I, 1884, p. 41.—Miller, North Amer. Geol. and Pal., 1889, p. 201.—Pocta, Syst. Sil. Centre Boheme, VIII, Pt. 1, 1894, p. 201.—Wiman, Natural Science, IX, 1896, p. 246.—Roemer and Frech, Leth. geog., I Theil, Leth. Pal., I, 3 Lief., 1897, p. 579.—Ruedemann, New York State Mus., Mem. 7, 1904, p. 587.

Ptilograpsus Nicholson, Ann. and Mag. Nat. Hist. (4), I, 1868, p. 239; Mon. Brit. Graptolitidæ, 1872, p. 126.

The generic characters of *Ptilograptus* were given by Hall (1865) as follows:

Frond plantlike, rooted? simple or branching. Branches and branchlets plumose, the pinnules rising alternately on opposite sides of the branches; celluliferous on one face only; branches cylindrical or flattened. Substance corneous, dense; apparently smooth exteriorly, or corrugated by compression or during fossilization.

Genotype.—Ptilograptus plumosus Hall. Tetragraptus zone of Quebec group in Canada.

PTILOGRAPTUS FOLIACEUS Spencer.

Ptilograpsus foliaceus Spencer, Canadian Nat., VIII, 1878, pp. 458, 462.

Ptilograptus foliaceus Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 565, 591, pl. 6, fig. 7; Bull. Mus. Univ. State Missouri, I, 1884, pp. 15, 41, pl. 6, fig. 7.—Miller, North Amer. Geol. and Pal., 1889, p. 201, fig. 210.—Gurley, Journ. Geol., IV, 1896, pp. 100, 309.

The original description is as follows:

Frond bipinnately branching. The slender branches are plumose, with delicate pinnules rising alternately from the opposite sides of the branchlets. There are angular openings on one side of the pinnules, whilst on the other there are indistinct corrugations. When viewed from the face, the cellules appear as oval impressions.

Fig. 18.—Ptilograptus foliaceus Spencer. The type-specimen and a branch enlarged. (After Spencer.)

The branches seldom exceed more than half an inch in length and all appear to originate from nearly the same place on the axis. From these numerous parallel pinnules occur on each side of the axis (sometimes as many as sixteen). The pinnules seldom exceed the fourth of an inch [5 mm; 1884] in length and rise at a very acute angle [by the pinnules being regularly arranged; 1884]. Even if separate branches be found they are easily recognized. They appear to have been attached, but from the specimens before me the radicle seems to have been broken off.

Like the other members of this group the texture is corneous, but sometimes replaced by pyrites. This species closely resembles the *P. plumulosa* of the Quebec group, but is smaller (three-fourths of an inch) and finer in structure, with the relatively [fewer and; 1884] longer pinnules.

It occurs in the Niagara limestone at Hamilton, Ontario.

The following notes are by Doctor Gurley:

The description of 1884 adds that there are usually three or four branches originating from near the same place on the short stipe, giving a lobed appearance to the frond. The branches are rather more than 1 cm. long. The cells occur on the lower sides of the branchlets (or pinnules). In 1 mm. there are 2 cells and 2 intercellular spaces. The slender branchlets are about 0.33 mm. thick, and the whole frond is never more than 2 cm. wide.

One specimen occurs, so labeled, in the Spencer collection, from the Niagara dolomite, Hamilton, Ontario. After close study of it, I have concluded that it is too obscure to add much to existing data, which amply suffice for the recognition of the species in Hamilton collections. I find the branches about 0.25 to 0.3 mm. wide, and the thecæ 50 to 55 in 25 mm. Whether or not the generic reference is correct, it is the most natural provisional one, and may stand, pending better material.

Genus DICTYONEMA Hall.

Dictyonema Hall, Amer. Journ. Sci. (2), XI, 1851, p. 401; Nat. Hist. New York, Pal., II, 1852, p. 174.—Pictet, Traité de Pal., 2d ed., IV, 1857, p. 171.—Hall, Geol. Surv. Canada, Rep. Progr. for 1857, 1858, p. 142; Canadian Nat. Geol., III, 1858, p. 174; Nat. Hist. New York, Pal., III, 1859 [1861], p. 15; Geol. Surv. Canada, Decade 2, 1865, p. 136.—Salter, Mem. Geol. Surv. Great Britain, III, 1866, p. 331 (2d ed., 1881, p. 535).—Hall, 20th Rep. New York State Cab. Hist., 1868, p. 218 (rev. ed., 1868 [1870], p. 252).—Nicholson, Mon. Brit. Graptolitidæ, 1872, p. 129.—Dames, Zeits. d. d. geol. Gesell., XXV, 1873, p. 383.—Zittel, Handbuch d. Pal., I, 1879, p. 289.—Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 562, 572; Bull. Mus. Univ. State Missouri, I, 1884, p. 22.—Miller, North Amer. Geol. and Pal., 1889, p. 185.—Holm, Bihang till K. Sv. Vet.-Akad. Handl., XVI, Afd. IV, No. 7, 1890, p. 4.—Moberg, Geol. Foren. Stockholm Forhandl., XIII, 1891, p. 216.—Matthew, Trans. Royal Soc. Canada, IX, sect. IV, 1892, p. 33.—James, Journ. Cincinnati Soc. Nat. Hist., XIV, Pt. 2, 1892, p. 153.—Moberg, Geol. Foren. Stockholm Forhandl., XVI, 1894, p. 236.—Tornquist, Geol. Foren. Stockholm Forhandl., XVI, 1894, p. 380.—Počta, Syst. Sil. Centre Boheme, VIII, Pt. 1, 1894, p. 190.—Pritchard, Proc. Royal Soc. Victoria, new ser., VII, 1895, p. 27.—Wiman, Natural Science, IX, 1896, p. 243.—Koken, Die Leitfossilien, 1896, p. 327.—Gurley, Journ. Geol., IV, 1896, p. 81.—Frech, Leth. geog., I Th., Leth. Pal., I, 3 Lief., 1897, p. 557.—Roemer and Frech, Leth. geog., I Th., Leth. Pal., I, 3 Lief., 1897, p. 569.—Walther, Zeits. d. d. geol. Gesell., XLIX, 1897, pp. 250, 253.—Grabau, Bull. Buffalo Soc. Nat. Sci., VI, 1899, p. 119; Bull. Buffalo Soc. Nat. Sci., VII, 1901, p. 133; Bull. New York State Mus., IX, 1901, p. 133.—Ruedemann, New York State Mus., Mem. 7, 1904, p. 591.

Dictyograptus Hopkinson and Lapworth, Quart. Journ. Geol. Soc. London, XXXI, 1875, p. 667.—Moberg, Geol. Foren. Stockholm Forhandl., XVI, 1894, p. 236.—Tornquist, Geol. Foren. Stockholm Forhandl., XVI, 1894, p. 380.

A very complete history of this genus (consisting of about forty pages of typewritten manuscript) was compiled by Doctor Gurley,

but a review and also a discussion of the generic characters was presented by Doctor Ruedemann before the Gurley manuscript came into his possession. To Doctor Ruedemann's excellent work the reader is referred.

Genotype.—Dictyonema retiforme (Hall). Niagaran (Rochester) shale, New York.

DICTYONEMA RETIFORME (Hall).

Gorgonia ? reteformis Hall, Rep. Surv. 4th Geol. Dist. New York, 1843, p. 115, text fig. 1.

Dictyonema retiformis Hall, Nat. Hist. New York, Pal., II, 1852, p. 174, pl. 40F, figs. 1 *a*, *b*.—Lincklaen, 14th Rep. New York State Cab. Nat. Hist., 1861, p. 55, pl. 7, fig. 1.—Hall, Geol. Surv. Canada, Decade 2, 1865, p. 12, fig. 10; 20th Rep. New York State Cab. Hist., 1868, p. 178, text fig. 11 (rev. ed., 1868, 1870, p. 210, text fig. 11).—Nicholson, Mon. Brit. Graptolitidæ, 1872, p. 129, text fig. 69.

Dictyonema retiforme Spencer, Can. Nat., X, 1882, p. 165; Trans. Acad. Sci. St. Louis, IV, 1884, p. 573, pl. 3, figs. 1, 2; Bull. Mus. Univ. State Missouri, I, 1884, p. 23, pl. 3, figs. 1, 2.—Miller, North Amer. Geol. and Pal., 1889, p. 185, text fig. 168.—Počta, Syst. Sil. Centre Boheme, VIII, 1894, p. 192.—Gurley, Journ. Geol., IV, 1896, pp. 96, 308.—Roemer and Frech, Leth. geog., I Th., Leth. Pal., I, 3 Lief., 1897, p. 575, text fig. 145.—Grabau, Bull. New York State Mus., IX, 1901, pp. 133, 134, text fig. 27; Bull. Buffalo Soc. Nat. Sci., VII, 1901, p. 133, text fig. 27.—Ruedemann, New York State Mus., Mem. 11, 1908, p. 155, text fig. 64.

This fine species, the genotype of *Dictyonema*, is a well-known although rather rare form in the Niagaran (Rochester) shale of New York. In Canada the species is confined to the earthy dolomites and shales beneath the chert bed of the more typical dolomites. Doctor Gurley has prepared the following redescription, based upon the types and other specimens studied by him:

Polypary rather strongly radiate, with the branches usually about 0.8 mm. wide (a few as narrow as 0.6 mm., a few swelling out to 1 mm., particularly immediately below a bifurcation); about 15–17 in 25 mm. of width in the basal portion, and in young specimens frequently somewhat more slender, more tortuous (with slight tendency to zigzag) and somewhat farther apart; the interspaces consequently as wide as, or slightly wider than, the branches. Dissepiments mostly transverse (some are slightly oblique, a few very oblique); generally slender (about 0.2 mm.), but a few reach 0.3 mm., or rarely 0.4 mm. Meshes mostly oblong; a number of careful measurements has shown me that the most usual (the typical) length is on the average 1.5 mm. (between 1 and 2 mm.), but longer ones are seen, from covering up or destruction of the intervening dissepiments, which condition in favorable cases can be proven. Rarely two successive dissepiments are not farther apart than 0.5 mm. This almost invariably results from the two dissepiments diverging from a common point of origin on one branch.

Doctor Ruedemann has published the following on the species:

It is by no means so common in our Niagara beds as one should suspect from its long bibliographic list or conclude from the direct statement of some authors that it is abundant in the New York rocks; in fact, it is one of the least common of the graptolites of our Rochester shale and all the references are excerpts of Hall's original description. I have seen altogether not more than half a dozen specimens, including Hall's types, and have not been able to find one which would reveal the form of the thecæ.

Remarks.—D. retiforme is a remarkably stately graptolite, possessing wide-open, funnel-shaped rhabdosomes, fragmentary specimens of which with a diameter of no less than half a meter have been observed; and the size of the branches and the meshwork are coarse in proportion. Pocta has compared it to the Bohemian *D. grande* Barr[ande], also a Siluric form, and pointed out the differences between the two.

Horizon and locality.—The two specimens here figured are from the more shaly strata (beds 9–11 of section) beneath the cherty dolo-

FIGS. 19, 20.—DICTYONEMA RETIFORME HALL. A SMALL RHABDOSOME SHOWING THE CENTRAL PORTION AND A PORTION OF A LARGER SPECIMEN.

mite at Hamilton, Ontario. Both specimens are in the Spencer collection. The types of the species are in the American Museum of Natural History.

DICTYONEMA CRASSIBASALE Gurley, new species.

Plate 3, figure 1.

Dictyonema gracilis SPENCER (not HALL), Canadian Nat., VIII, 1878, p. 458; X, 1882, p. 165.

Dictyonema gracile SPENCER, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 573, 574, pl. 2, figs. 2, 3; Bull. Mus. Univ. State Missouri, I, 1884, p. 24, pl. 2, figs. 2, 2a, 3.

This abundant species has hitherto been identified in the Hamilton collections as *Dictyonema gracile* Hall, but close comparison with Hall's types led Doctor Gurley to propose the above new name.

After quoting Hall's description of *D. gracile*, Spencer says of the present form:

In this species the branches are much more slender than in *D. retiforme*, averaging about half a millimeter in breadth and twice that distance apart. The branches are regularly arranged and form fan-shaped fronds, but many specimens indicate the cyathiform structure while living. Though the margins are generally even, yet in one fine specimen the terminations of the branches are irregular. The fronds converge to what is evidently a noncelluliferous radicle, and in size the finest specimens are as much as 10 cm. high and 6.5 broad.

FIGS. 21, 22.—DICTYONEMA CRASSIBASALE, NEW SPECIES. TWO RATHER SMALL RHABDOSOMES SHOWING THE PROXIMAL PORTION.

The transverse filaments, which are noncelluliferous, are from four to five times as far apart (sometimes much farther) as the branches; or are frequently obliterated, or almost so. The texture is corneous.

The celluliferous structure is shown in very few specimens. However, one specimen in particular, which I obtained from Mr. A. E. Walker, of Hamilton, removes all doubt as to the character of the cellules. On one side of the branch there is a slender solid axis, in the other there are inserted cylindrical calycles which penetrate the common canal (or cœnosarc) almost to the axis. The cells have their own distinct cell walls; they are cylindrical in form, about 0.5 mm. long and 0.35 mm. in diameter. The portion of the cell towards the orifice

overlies the base of the next cell, so that there are from 25 to 32 calycles in the length of a centimeter. More frequently only circular, or ellipsoid, elevated (sometimes depressed) points mark the former abodes of the polypites, which, being surrounded by a denser texture, have not yielded to the pressure which has flattened the walls of the common canal. The irregular striæ and depressions on the stipes and branches are probably occasioned by the unequal flattening of the canal and celluliferous portions of stipes.

This species is the most easily obtained of the fossils of the group, though good specimens are very uncommon. Generally we must identify them by the relative size and arrangements of the branches and filaments, or, in more perfect specimens, by the form of the frond.

Doctor Gurley described *D. crassibasale* as follows:

Polypary, sometimes attaining a great size (one specimen indicates a diameter for the whole polypary of nearly half a meter), usually, however, of more

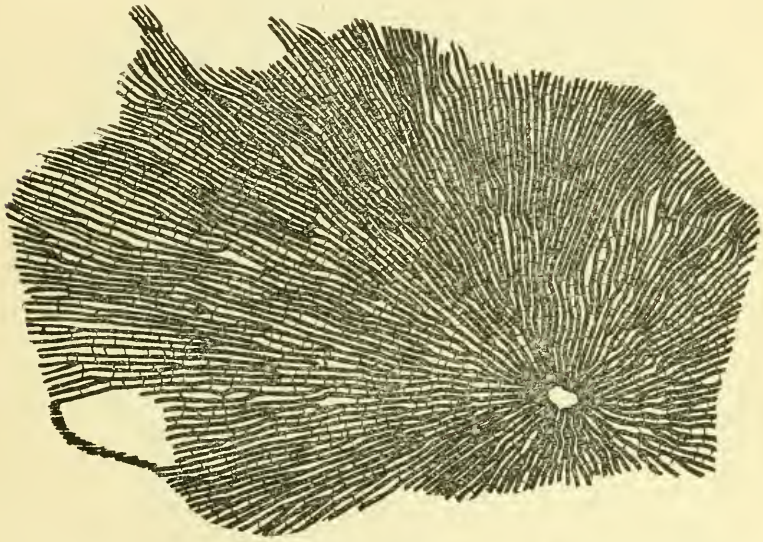


FIG. 23.—DICTYONEMA CRASSIBASALE, NEW SPECIES. A COMPRESSED INFUNDIBULIFORM RHABDOSOME.

moderate dimensions, cyathiform, consisting of parallel branches which radiate almost straight outward, but which are slightly flexuous in portions of their course. Their typical width is 0.5–0.6 mm. Some, however, especially distally, are as narrow as 0.4, and a few of the basal branches reach 0.8 mm. The branches are set 25–30 in 25 mm. of width, the number tending to reach the lower figure proximally and the higher figure distally. Distally, also, especially in fragments of large polyparies, the branches are sometimes as many as 35 in 25 mm., but not, I believe, except where distortion has occurred, perhaps from the dissepiments being more delicate in the younger portions of the polypary, or from greater post-mortem dissociation of the more flexible distal portion. Distally, too, the branches not infrequently, even in a normal polypary, will be seen to be quite tortuous and the meshes more irregular. Bifurcations occur at irregular and increasingly longer intervals. They are U-shaped, their sides often tending to bow outward and then to approach each other above. It is

especially around the bifurcations that the meshwork tends to depart from regularity and the branches to become flexuous. The dissepiments are all very slender, and are very numerous. They are all transverse or only very slightly oblique. Most of them are 1 mm. apart, though on a general average there may probably be as few as 20 in 25 mm. The greatest distance between consecutive dissepiments seems about 1.5 mm. Occasionally two may be very

FIG. 24.—DICTYONEMA CRASSIBASALE, NEW SPECIES. A COMPRESSED, FRAGMENTARY RHABDOSOME.

close together (0.4 mm.). Of course, being so very slender and the branches being comparatively stout, it often happens that an apparently well-preserved polypary may show the branches well preserved though the dissepiments have suffered. The meshes are rectangular, except where flexuosity of the branches renders them irregular. The thecæ, or rather indications of them in the form of oval elevations, are frequently well preserved, so frequently and so well

that this feature serves, in Hamilton collections, as a rather good mark of the species. They are about 55–60 in 25 mm.

Horizon and locality.—By far the most common species of the genus in the chert-dolomite series at Hamilton, Ontario. I count 38 specimens, which include only a few (selected from many) in the Hall and New York State collections; also one in the Spencer collection labeled "*Dictyonema gracile*."

In normal polyparies this species is easily distinguished from *D. gracile*. Its most characteristic features are the fibrous root, the heavier polypary, especially the much heavier branches at the base, the much more numerous dissepiments, and the fewer branches in 25 mm. of width, and (in Hamilton collections) the often well-preserved thecal elevations. Distal fragments of the two species (which, moreover, are rather more apt to be worn) are not always so easy to separate; but those of the present species are apt to be very extensive and

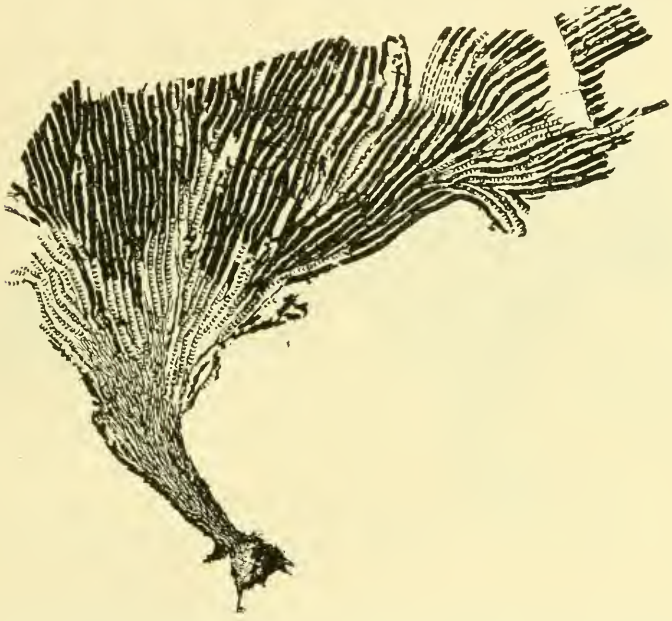


FIG. 25.—DICTYONEMA CRASSIBASALE, NEW SPECIES. RHABDOSOME PRESERVING THE FIBROUS PROXIMAL PORTION AND SHOWING THE THECÆ, ×1.5.

somewhere to yield characteristic marks. Usually, of course, they are to be identified by comparison with more perfect specimens.

The species to which this is most closely related is certainly *D. splendens*. Of that species I have but one specimen, so that I am unable to determine what range of variation it may present. Of the present one, however, I have nearly forty specimens, and with no one of them could I consider Billing's specimen as cospecific.

After a careful study I am convinced that this is the species which Spencer describes as *D. gracile* Hall. I base this opinion on his figures, particularly figure 3, the thecæ in which could, as far as the material before me goes, only belong to this species; and on his statements that it has a "noncelluliferous radicle," and that it is the species most easily obtained. Indeed, this species may be known in Hamilton collections by its very great frequency, it being by far the most common species.

Cotypes.—Cat. No. 55297, U.S.N.M.: Nos. 13502, 13504, Walker Museum, University of Chicago.

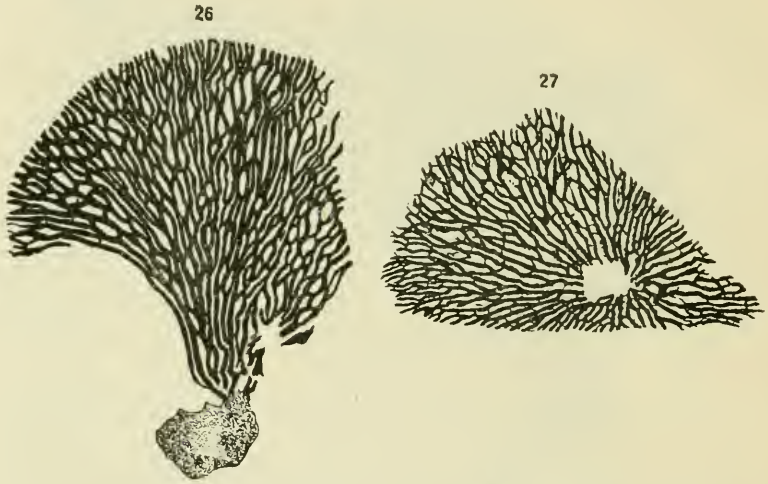
DICTYONEMA POLYMORPHUM Gurley.

Plate 4, figure 4.

Dictyonema tenellum SPENCER, Trans. Acad. Sci. St. Louis, IV, 1884, pl. 1, fig. 13 (not the description, p. 576); Bull. Mus. Univ. State Missouri, I, pl. 1, fig. 13 (not the description, p. 26).

Calyptograptus subrectiformis (part) SPENCER, Trans. Acad. Sci. St. Louis, IV, pl. 4, fig. 2; Bull. Mus. Univ. State Missouri, I, 1884, pl. 4, fig. 2.

Dictyonema polymorphum Gurley MS., RUEDEMANN, New York State Mus., Mem. 11, 1908, p. 158, pl. 2, fig. 3; pl. 3, figs. 4, 5, 6; p. 160, text figs. 60–72.



FIGS. 26, 27.—DICTYONEMA POLYMORPHUM GURLEY. 26, RHABDOSOME RETAINING DISK (PLESIOTYPE); 27, A COMPRESSED SPECIMEN (HOLOTYPE) WITH CENTRAL PORTION. (SEE ALSO PL. 4, FIG. 4.)

Doctor Gurley's elaborate description of this species has been published by Ruedemann,[a] but is repeated here for the sake of completeness:

Polypary originally cyathiform, circular or flabellate on the rock, when flabellate often evenly semicircular in the largest specimen seen, 85 mm. in diameter; originating in and sessile upon a carbonaceous "disk," which in one specimen is seen to have its walls riddled with pores. Branches measuring 0.6 mm. in width on the average, hardly ever as narrow as 0.3 mm. (as Spencer states them to average), 0.4 mm. being, with rare exceptions, the minimum and 0.8 the maximum. Branches varying equally in character, being sometimes nearly straight, at others irregularly sinuous, and inosculating, as in *Desmograptus*. Occasionally the adjacent margins of two branches coalesce. The branches end in long drawn out, spike-like points. Very often—usually, in fact—shortly before their termination, they bifurcate, U like, the termina-

[a] New York State Mus., Memoir 11, 1908, p. 158.

tion thus being forcepslike. This mode of ending is quite characteristic of the species. Apparently this spike-like forking of the branches may occasionally take place in the wall of the polypary below the summit, and the spikes then seem to serve the same purpose as dissepiments, bracing the polypary. As the fossil usually lies on the stone, the number of branches in 25 mm. of width is exceedingly variable, generally from distortion. In places where the polypary is evenly and smoothly laid out and the meshwork perfectly regular, however, the number is about 22 (20–25) near the base and about 25–30 at the periphery. The dissepiments are of medium thickness (about 0.15–0.4 mm.) and are either perpendicular or highly inclined (say 45°) to the branches, and this combination in the same specimen forms a striking feature of this species, a feature well shown in Spencer's figure (text fig. 29). Meshes very variable in shape, corresponding to the irregularity in the branches and dissepiments. In one specimen I find meshes from 1.5 to 6 mm. long, but the longest are in one or two cases demonstrably subdivided, and probably 3 mm. is about the greatest length. From obscure indications the thecæ seem to be set about 50 in 25 mm. (Spencer gives the number as 60.)

One specimen (text fig. 26) in the Hall collection shows the base fairly well preserved. This measures about 12 by 8 mm. and shows a unique structure. The margin is in places sharply defined, and is either convex or concave. The surface is uniformly dotted with very numerous elliptic or circular pores, which hardly reach 0.2 mm. in the greatest diameter, and which have a well-defined rim-like margin. They seem to have a somewhat regular arrangement, in rows and are separated by interspaces narrower than their own diameter. The texture of this "disk," like that of the network, is carbonaceous.

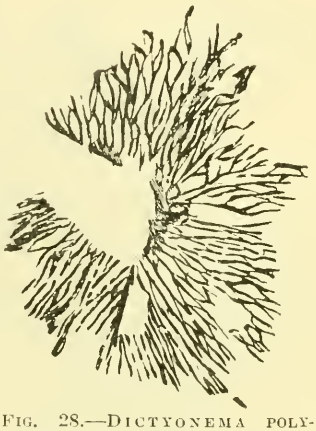


FIG. 28.—DICTYONEMA POLYMORPHUM GURLEY. ONE OF SPENCER'S TYPES OF CALYPTOGRAPTUS SUBRETIFORMIS. (AFTER SPENCER.)

Horizon and locality.—Twenty-four specimens from the Niagara chert and glaciated chert beds, Hamilton, Ontario.

In this count are included two specimens in the Spencer collection, labeled "*Calyptograptus subretiformis.*" While these two specimens are very poor, still without question they belong here and not with *C. subretiformis.* On the other hand, it is quite evident to me that these two specimens are of the species which furnished the basis for Spencer's figure 2, which differs considerably from his figure 1, and his figure 2 should, therefore, I believe, be added to the synonymy of *D. tenellum.*

This species is exceedingly variable in appearance. It is sometimes spread out circularly, sometimes flattened flabelliformly from the side. Its most characteristic features are the average thickness of 0.6 mm. (not 0.3 mm., as Spencer's text states), their number of 20–25 in 25 mm. of width in the proximal and of 25–30 in the distal portion of the polypary. But in this species, more than in others, it is possible to get almost any number, unless the place for counting be carefully chosen, where the meshes are regularly laid down and not distorted. Further, the combination in the same specimen of transverse dissepiments and of dissepiments inclined at about 45° to the branches, with,

in other places, modes of connection (coalescence of approximated lateral margins, curving together and entire fusion of adjacent branches) usual in *Desmograptus*, thus producing a great variety of mesh form, constitutes a striking feature in the present species.

This species is one of the most common graptolites in the Rochester shale of New York, as well as in the limestone at Hamilton, Ontario. Quoting Doctor Ruedemann:

This form is easily distinguished from both its associated congeners, *D. rectiforme* and *D. gracile*, by its more irregularly bent branches and the oblique direction of the dissepiments. By these characters it seems to lead directly to *Calyptograptus subretiformis* Spencer with which it is also associated.

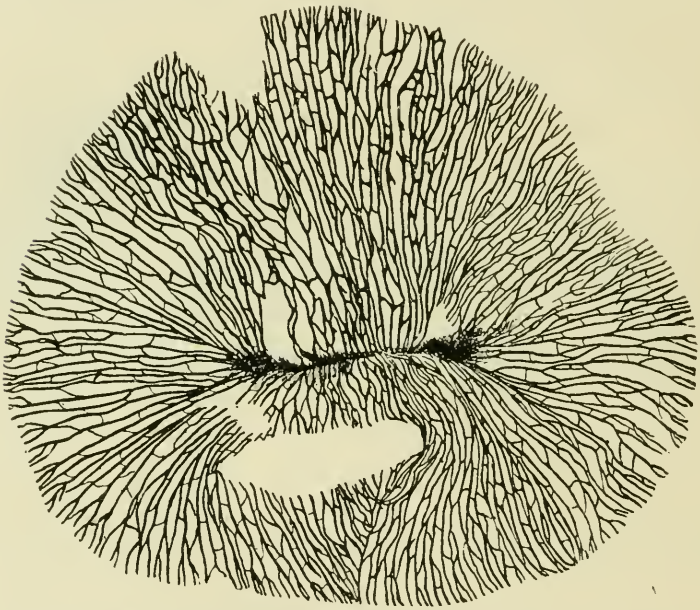


FIG. 29.—DICTYONEMA POLYMORPHUM GURLEY. SPENCER'S FIGURED TYPE OF DICTYONEMA TENELLUM. (AFTER SPENCER.)

Holotype (selected by Ruedemann).—Cat. No. 54278, U.S.N.M.
Plesiotype.—Walker Museum, University of Chicago, No. 13517.

DICTYONEMA SUBRETIFORME (Spencer).

Calyptograpsus subretiformis SPENCER, Canadian Nat., VIII, 1878, pp. 458, 460.

Calyptograptus subretiformis SPENCER, Trans. Acad. Sci. St. Louis, IV, 1884, p. 578, pl. 4, fig. 1 (not fig. 2); Bull. Mus. Univ. State Missouri, I, 1884, p. 28, pl. 4, fig. 1 (not fig. 2).

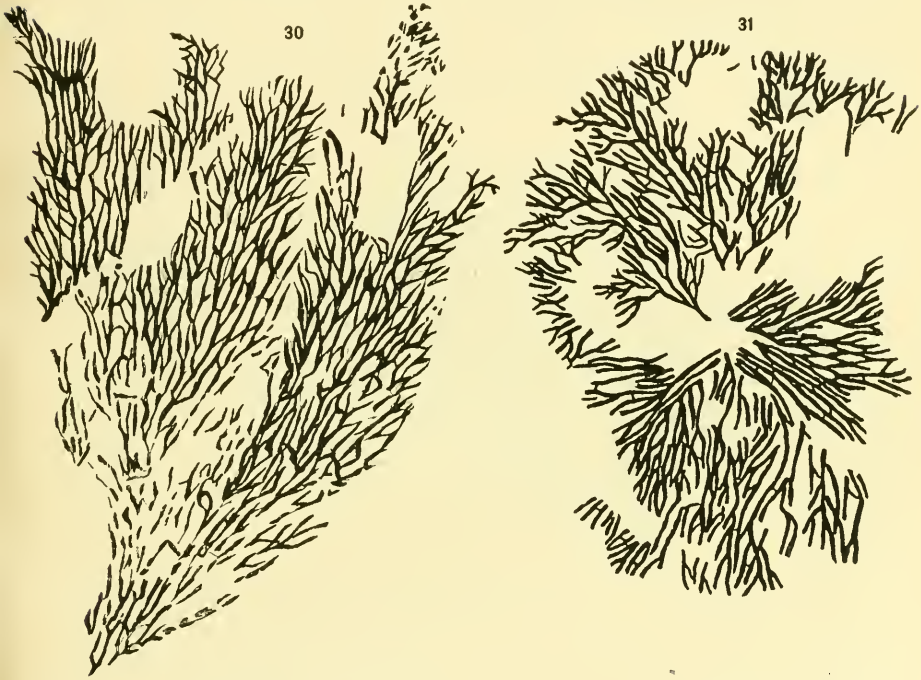
Dictyonema subretiforme RUEDEMANN, New York State Mus., Mem. 11, 1908, p. 162, pl. 2, figs. 1, 2.

This species is closely related and similar to the preceding form, *D. polymorphum*, both of which have been described and illustrated by

Ruedemann. Spencer's original description, with additions from his description of 1884 contained in brackets, is given below:

Frond circular, but cyathiform in its growing state. There are numerous bifurcating branches, which in the fossil condition imperfectly unite or overlie each other, producing a kind of fine network with irregular sub-rhomboidal [ellipsoidal] interstices. In texture it is corneous, having the branches marked with striations of a sub-rhomboidal form.

In this species the branches are much finer (but little more than one-eightieth of an inch in width [0.35–0.75 mm.]) than in *C. cyathiformis*, with more numerous and irregular bifurcations, producing a netted appearance. The original matter is often replaced by pyrites. The fronds are not generally more than two inches



FIGS. 30, 31.—DICTYONEMA SUBRETIFORME (SPENCER). 30, ONE OF SPENCER'S TYPES OF CALYPTOGRAPTUS SUBRETIFORMIS. (AFTER SPENCER.) 31, A LARGE EXPANDED RHABDOSOME FROM THE ROCHESTER SHALES OF NEW YORK. (COPIED FROM RUEDEMANN.)

in diameter. Only a few specimens have been found, and these show some varietal differences.

This species was found in the Niagara limestone [principally in the shaly dolomites beneath the chert bed], Hamilton, Ontario, by Colonel Grant.

To this description Gurley adds the following:

Measurements of a number of branches show that these nearly all fall between 0.4 mm. and 0.6 mm., 0.4–0.5 being the dimensions usual in the distal portion for the branches exclusive of the terminal twigs. The more proximal stems measure 0.6 mm., and the thickest seen (in one specimen only) reached 0.8 mm. Corresponding to the straggling aspect of this species almost any number of branches may be counted transversely, but if portions be selected where the branches are

at fairly regular distances apart and the meshes consequently of pretty uniform width, the number will be found to be about 25 (say 23–27).

Ruedemann[a] says, in connection with the generic position of the species:

As both Spencer's drawings and our material show, these [generic] characters are not retained in his second species, *C. subretiformis*. The latter clearly possesses dissepiments, which, however, are so oblique that they appear as bifurcations [see Spencer's figure, here copied.] *Dictyonema polymorphum* Gurley indicates transition from a typical *Dictyonema* with rectangular meshes to this irregularly meshed form. The clearly closer relationship of the present species to *Dictyonema polymorphum* than to *C. cyathiformis* has induced us to place it under the former genus and to restrict *Calyptograptus* to forms which retain the diagnostic characters of the genotype.

DICTYONEMA TENELLUM Spencer.

Plate 2, figure 4.

Dictyonema tenella Spencer, Canadian Nat., VIII, 1878, pp. 458, 459.

Dictyonema tenellum Spencer, Canadian Nat., X, 1882, p. 165; Trans. Acad. Sci. St. Louis, IV, pp. 564, 576 (not pl. 1, fig. 13); Bull. Mus. Univ. State Missouri, I, pp. 14, 26 (not pl. 1, fig. 13).—Miller, North Amer. Geol. and Pal., 1889, p. 185.—Gurley, Journ. Geol., IV, 1896, pp. 96, 308.

The original description is as follows:

Frond cyathiform in growing state, but usually circular, although occasional specimens have a flabellate form in the rock. The branches are uniform, nearly parallel, and radiate from the center with very few bifurcations; in width they vary from one one hundred and twentieth to one-eightieth of an inch, but uniform in the same specimen. The branches are connected at short intervals by transverse dissepiments; while the margin of the frond is remarkably constant. The surface is striated, and the texture has a corneous character like that of the other species of this group.[b]

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[a] New York State Mus., Mem. 11, 1908, p. 164.

[b] Here is interpolated in the description of 1884, a paragraph which I footnote, being convinced that with the exception of the statement that "between the branches there are not usually spaces as great as (or greater than) their own width," it has no reference to the species now under consideration.

"In the best specimens distinct ellipsoid pits are arranged along the sides of the branches, marking the positions of the calycles, these having the longer diameter equal to half a millimeter and their shorter occupying two-thirds of the width of the stipe. There are about twenty-four of these calycles arranged longitudinally in the length of a centimeter. In specimens less perfectly preserved the bars connecting the branches are almost obliterated, and in those in a better state of preservation they are placed from 2 to 3 mm. apart, while between the branches there are not usually spaces as great as (or greater than) their own width."

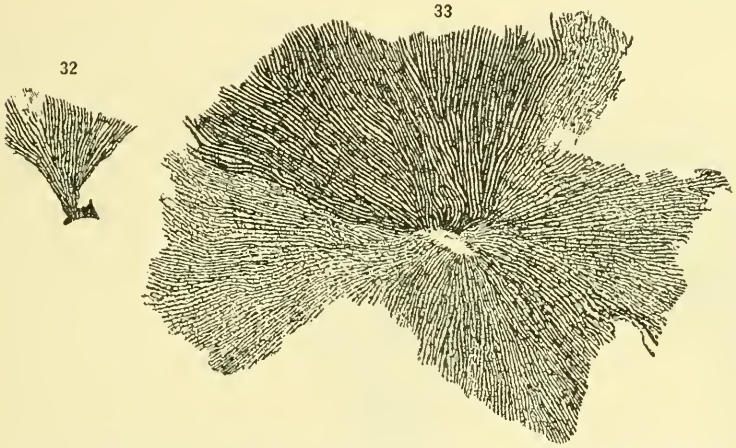
Respecting the species to which he does refer, I can only say that in my experience, *D. crassibasale* more usually than any other species, has the thecæ preserved, and that those structures in *crassibasale* could be described in about the words used. But in no species could be both 0.5 mm. long, and 24 in 1 cm.—R. R. Gurley.

As the connecting filaments are very fine, owing to imperfect preservation, they are not always distinct over the whole surface of the frond. This species is easily distinguished from *D. gracilis*—even in fragments—by the branches being exceedingly fine (about one-hundredth of an inch in width), with scarcely that distance between them, and with no approach to the dendritic form of that species. The frond maintains its character even in the young state. The largest frond is three and one-half inches in diameter.

It occurs in the Niagara limestone [dolomitic limestones of the cherty beds and in the underlying more shaly rocks; 1884] at Hamilton, Ontario. The specimen described was obtained by Lieutenant-Colonel Grant, and presented to the writer.

Spencer's description of 1884 adds, that the dissepiments are very delicate, and the margin entire. He further says:

This species is easily distinguished from *D. gracile* [=*D. crassibasale* Gurley] by the branches being much finer, less diverging, and with more bifurcations, by the transverse bars being more closely arranged, and by the frond being



FIGS. 32, 33.—DICTYONEMA TENELLUM SPENCER. 32, A SMALL EXAMPLE PRESERVING THE BASAL PORTION. (BY R. S. BASSLER.) 33, A LARGER RHABDOSOME.

regularly circular, with no general bush-like form like that seen in most specimens of *D. gracile* [*crassibasale*]. The largest frond is 9 cm. in diameter.

Gurley's description of the species is as follows:

Polypary cyathiform, in the flattened state radiating from a center; proximal extremity only indistinctly visible in one specimen (text fig. 32), appearing to consist of some kind of a bulbous or fibrous root. Branches straight, mostly 0.3–0.35 mm. wide; a few as narrow as 0.25; occasionally one as wide as and none wider than 0.4 mm. Number of branches transversely in 25 mm., proximally about 45, distally 50–55. Interspaces consequently rarely as wide as and usually much narrower than branches. Minimal length of meshes about 0.5 mm., maximum about 1 mm. Thecæ invisible. Dissepimenta of about medium thickness, straight or oblique.

The identification of this species I consider thoroughly made out. There is no other species at Hamilton, at least in my experience, to which Spencer's original description could refer. But in 1884 Spencer figured as *D. tenellum* a

totally different species, the one I have named *D. polymorphum*. It is very important to note that his description, too, has become tinctured with foreign elements, the whole of the second paragraph, with the possible exception of the statement that "between the branches there are not usually spaces as great as (or greater than) their own width," having no application to the present species.

Horizon and locality.—Not uncommon in the Niagara dolomite, chert, and glaciated chert at Hamilton, Ontario.

The originals of text figure 32 and Plate 2, figure 4, are in the National Museum, while the third figured specimen (fig. 33) belongs to the Spencer collection.

Plesiotypes.—Cat. No. 55300, U.S.N.M.

DICTYONEMA STENACTINOTUM Gurley, new species.

Plate 3, figure 2.

Gurley's description of this fine new species follows:

Polypary flabelliform, included within an angle of 35°, somewhat obscure at base; branches 0.6–0.8 mm. wide (in places apparently as narrow as 0.4 mm., but they are there not fully exposed, as the same branches elsewhere show in their course the full width); mostly parallel, in places curving irregularly, causing distortion of the meshwork; set 17–18 in 25 mm. of width. Dissepiments slender or thick, several reaching 0.6 mm. and but for their position being virtually indistinguishable from a nearly transverse branch. The majority are transverse, though many are more or less and some are quite oblique. Most are parallel-sided; a number are triangular. In general the meshwork is regular, the meshes rectangular. The most regular meshes vary in length between 1.5 and 2.5 mm. Distorted meshes may be as short as 0.5 mm., though more usually 1 mm. is the minimum. Only obscure indications of thecæ are seen.

FIGS. 34, 35.—DICTYONEMA STENACTINOTUM, NEW SPECIES. 34, HOLOTYPE. 35, A RHABDOSOME REFERRED SOMEWHAT DOUBTFULLY. (SEE ALSO PL. 3, FIG. 2.)

The above description refers to the type-specimen alone [fig. 34]. One other specimen [text fig. 35, Pl. 3, fig. 2], from approximately the same horizon, exhibits a general resemblance to the type, but with some differences. It may be described as follows:

Polypary known only in the form of a fragment of the meshwork; branches heavy (0.8 mm. wide), parallel, diverging only very slightly, bifurcating correspondingly rarely (the few successive bifurcations visible are 12–20 mm. apart); set 15 or 16 in 25 mm. of width. Dissepiments when unworn probably

always heavy (0.4, 0.6, 0.8 mm.), though as seen they are sometimes slender, usually transverse, sometimes oblique. Meshes coarse, rectangular, about 3 mm. or more in length, though occasionally one is seen as short as 1.5–2.5 mm. Apparently the length may reach 5 or even 6 mm., but in one mesh of this character two intermediate dissepiments can be made out on close observation. So that the superficial aspect of the fossil is not to be implicitly trusted.

Careful comparison with the three species (*ivebsteri, retiforme, percrassus*) to which this form comes nearest, shows it to be distinct from all; from the last two it may be known by the absence of the rapid radiation of the polypary.

Horizon and locality.—Two specimens in National Museum, both from the Niagara dolomite, Hamilton, Ontario.

Holotype and paratype.—Cat. No. 55299, U.S.N.M.

DICTYONEMA EXPANSUM Spencer.

Dictyonema expansum SPENCER, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 575, 576, pl. 2, fig. 1; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 25, 26, pl. 2, fig. 1.—GURLEY, Journ. Geol., IV, 1896, pp. 96, 308.

Spencer's original description is as follows:

Frond flabelliform, composed of slender, expanding, and bifurcating branches, diffusely arranged, and united laterally by slender filaments (often wanting); branches irregularly striated; texture corneous.

This species is clearly related to *D. gracile* in the relative size of the branches, but these are much more diffusely and irregularly arranged, with greater interspaces, which are from two to four times the width of the branches. The transverse filaments occur less frequently than in *D. gracile*. Fragments of this species are not always easily distinguishable from *D. gracile*, although the branches are looser and more spreading. The type specimen is 8 cm. high and about 16 broad, rising from a united base of five or six stipes.

Formation and locality.—Niagara limestones at Hamilton, Ontario.

Doctor Gurley describes a specimen of this species as follows:

There is in all the Hamilton collections but one specimen which I could by any possibility refer to Spencer's *expansum*. It may be described as follows:

Polypary 120 mm. high and 235 mm. broad; flabelliformly compressed, semicircular in outline, consisting proximately of eight parallel branches, and higher up of numerous branches, which are approximately straight (or with long, sweeping curves) and subparallel; the extreme lateral ones perpendicular to the median line of the polypary, nearly straight, the whole curvature occurring proximally in a short turn. Width of branches pretty uniformly 0.8 mm., one being occasionally seen 1 mm. wide. Distally the specimen is so worn that it is hard to say whether the full width is maintained to the periphery or not, but a few unworn branches there measure 0.8 mm. The branches are everywhere set about 17 in 25 mm. of width. Concerning the number of dissepiments, nothing can be said, the specimen being too much worn. No thecæ are visible.

Horizon and locality.—One specimen in Spencer's collection, labeled *Dictyonema retiforme*, from the Niagara dolomite, Hamilton, Ontario.

I can not say that I feel entire confidence in the identification, but I think this is Spencer's species. As above remarked, it is the only one in the collections which could be *expansum*, and it agrees as well with Spencer's descrip-

tion, and particularly with his figure, as a poorly preserved specimen could be expected to. Parenthetically, I may say that it seems distinct from all the

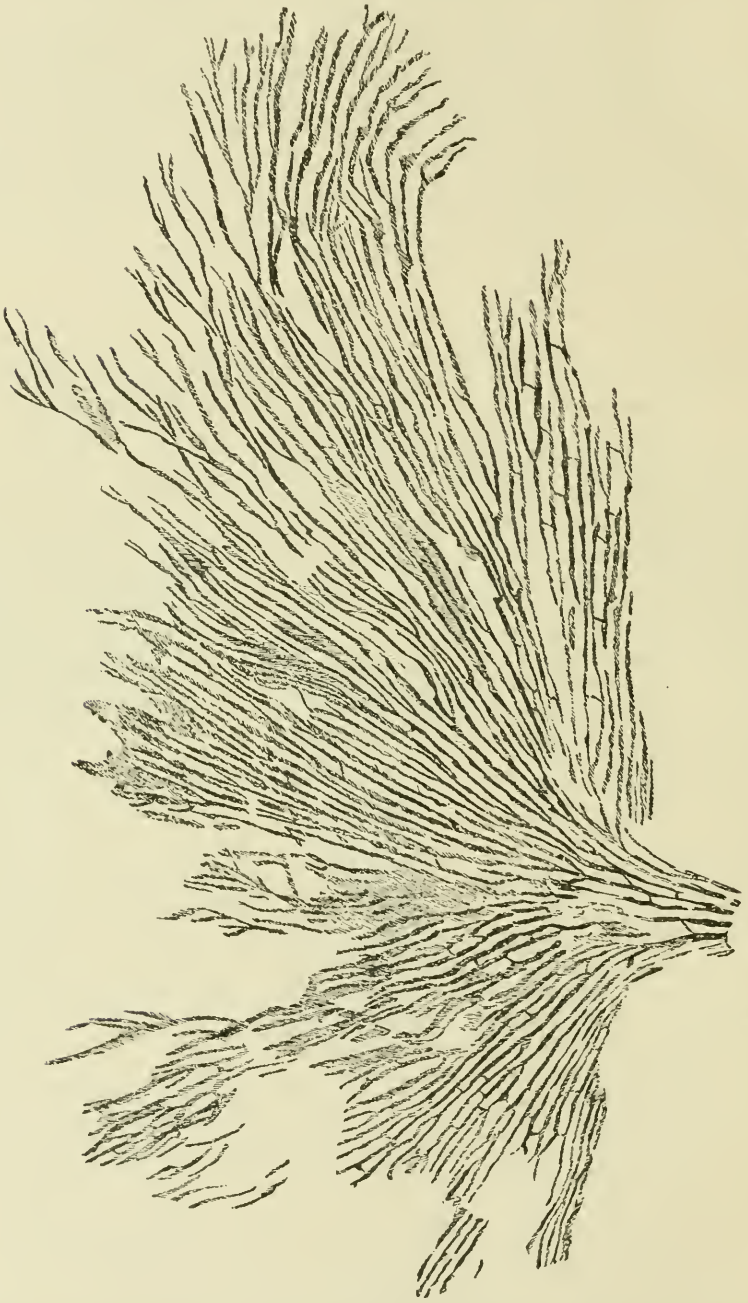


FIG. 36.—DICTYONEMA EXPANSUM SPENCER. THE ORIGINAL TYPE. (COPIED FROM SPENCER.)

other species at Hamilton. Among its distinctive marks may tentatively be named: The perpendicularity of the extreme lateral branches of the median

line of the polypary, and the restriction of the curvature of the branches within a short space toward their proximal end, the approximately straight course of

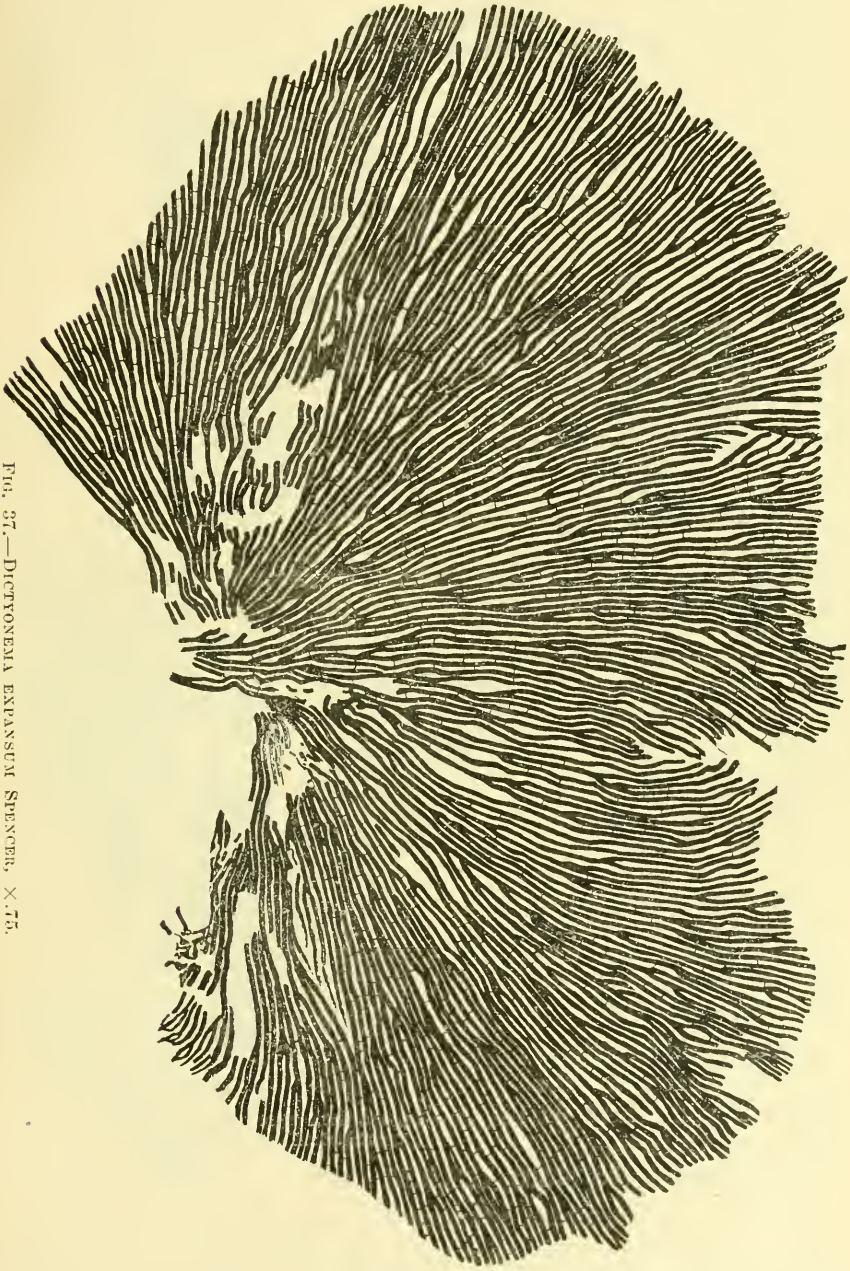


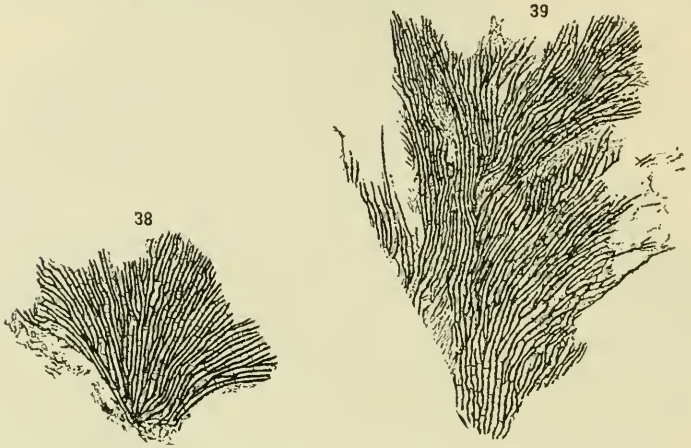
FIG. 37.—DICTYONEMA EXPANSUM SPENCER, ×.75.

the branches, and lastly, of course, the measurements. According to Spencer, the dissepiments are fewer than in *D. crassibasale* (his *gracile*).

DICTYONEMA FILIRAMUS Gurley, new species.

Gurley's description of this species is as follows:

Polypary varying from flabelliformly compressed, nearly and regularly semicircular, about 25–30 mm. in radius, to flabellate expansions 14 or more cm.



FIGS. 38, 39.—DICTYONEMA FILIRAMUS, NEW SPECIES. TWO SMALL RHABDOSOMES.

in diameter. Branches straight or uniformly curved, mostly 0.3 mm. wide, reaching 0.4 mm., especially near the base; set about 40 in 25 mm. (7–9 in 5 mm., the strong radiation preventing counting for longer distances.) Bifurcations narrow, tending to V-shape. Dissepiments exceedingly fine; rather uniformly 1 mm. apart, occasionally two as close together as 0.5 mm.; quite uniformly transverse. Meshes quite regular, rectangular. Too few thecæ are visible to permit of any accurate estimate of their number, but they seem to be something like 100 or more in 25 mm.

FIG. 40.—DICTYONEMA FILIRAMUS, NEW SPECIES. ×4 RHABDOSOME OF MEDIUM SIZE.

Horizon and locality.—Not uncommon in the dolomite and chert at Hamilton, Ontario.

Cotypes.—Cat. No. 55303, U.S.N.M.

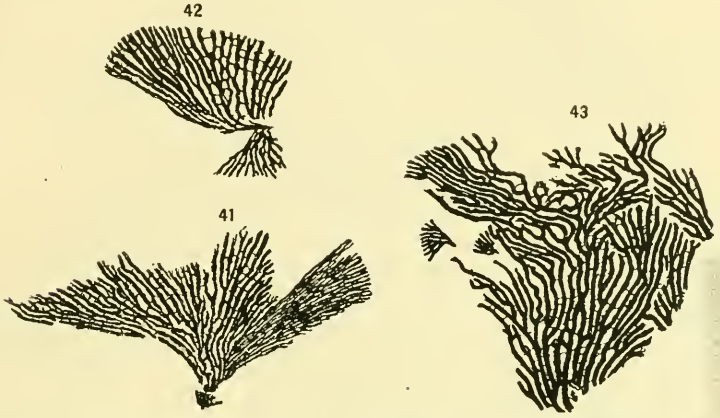
DICTYONEMA DESMOIDES Gurley, new species.

Plate 4, figure 3.

Gurley describes this species as follows:

Polypary cyathiform, flabelliformly compressed, tending to spread rather widely, with branches 0.5 mm. (0.4–0.6 mm.) wide, the central ones usually straight, or only slightly undulate, the lateral ones diverging moderately, or

sometimes extremely and often undulate or more or less tortuous, and really or apparently fusing *Desmograptus* fashion. In places where the meshwork is laid down evenly and without distortion there are about 30 branches in 25 mm. of width. Proximally the number may perhaps be somewhat less (say 27). Distally, especially laterally, where the branches are reflexed, and, in some places crowded, there may be 35 in 25 mm., a condition perhaps due to distortion. The interspaces then are, in general, narrower than the branches, and much narrower distero-laterally, where the latter are crowded. The dissepiments are heavy (0.2–0.4 mm. thick), and apparently somewhat remote, but the exact



FIGS. 41–43.—DICTYONEMA DESMOIDES, NEW SPECIES. 41, THE HOLOTYPE, A SMALL BUT RATHER COMPLETE RHABDOSOME. (BY R. R. BASSLER.) (SEE ALSO PL. 4, FIG. 3); 42, 43, PARATYPES. TWO FRAGMENTARY RHABDOSOMES.

distance cannot be stated. Meshes rectangular, elliptic, or irregular. Thecæ obscure, but apparently about 50 in 25 mm.

Horizon and locality.—Niagara chert, Hamilton, Ontario.
Holotype.—New York State Museum, Albany, New York.
Paratype.—Cat. No. 55304, U.S.N.M.

DICTYONEMA PERCRASSUS Gurley, new species.

Doctor Gurley's description is as follows:

Portion of the polypary seen (incomplete proximally) flabellate, radiating rather rapidly, the width increasing, in one specimen, in the longitudinal or radial distance of 30 mm. from 8.5 to 38 mm. and the branches from 7 to 21. The width thus increases more rapidly than the branches. The increased space is, however, taken up by the increased thickness of the branches, which, in proceeding from the base, rapidly increase to a width of about 0.8 mm. and at the periphery may reach 1 mm. Proximally a few are as narrow as 0.4 mm., but nearly all are 0.5 mm., and some measure 0.6 mm. Distally the interspaces are quite or very nearly as wide as the branches, but never wider. Proximally, however, they are about 1½ times as wide as the branches or (with the narrowest branches) even a little more. Proximally the number

FIG. 44.—DICTYONEMA PERCRASSUS, NEW SPECIES. A FRAGMENTARY RHABDOSOME.

of branches is about 20 in 25 mm. of width. Distally it ranges from 14 to 17. The dissepiments are not very slender (reaching a width of 0.2 mm. *ad max.*), straight or oblique, sometimes two diverging from a common point of origin on the branch. Length of meshes probably (when all the dissepiments are preserved and visible) not much exceeding 2 mm. The dissepiments are, in many places, obscure, but seem usually to be 1.5–2.0 mm. apart. Smallest complete meshes about 1 mm. long. Branches obscurely striate. Thecæ invisible.

Horizon and locality.—Glaciated chert beds, Niagara formation, Hamilton, Ontario.

This species is characterized especially by the very great thickness of its branches, the general radiating aspect of the polypary, and the small number of branches transversely.

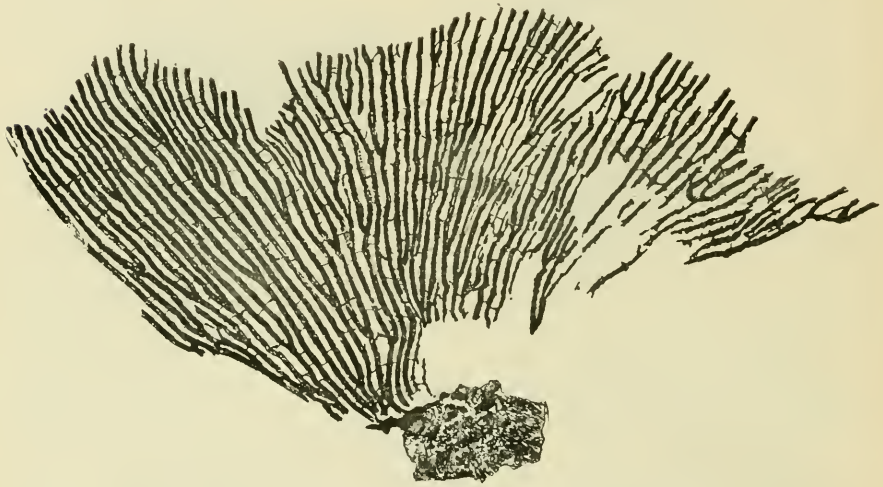


FIG. 45.—DICTYONEMA PERCRASSUS, NEW SPECIES. RHABDOSOME WITH BASAL ATTACHMENT.

Cotypes.—Collection of Walker Museum, University of Chicago. No. 13511; Spencer collection.

DICTYONEMA SPENCERI Gurley, new species.

Plate 4, figure 1.

Doctor Gurley's description follows:

Polypary circular or flabelliform, consisting of heavy branches, mostly about 0.8 mm. wide, some as narrow as 0.6 mm., set about 17–20 in the proximal portion and usually about 20–22 in 25 mm. of width in the peripheral portion of the polypary, nearly straight, subparallel, with about 4 or 5 bifurcations in their course toward the periphery. Dissepiments usually slender, though an occasional one reaches 0.5 mm., usually 1.5–2 mm. apart, and in many cases a 3 mm. interval is seen without any trace of an intermediate dissepiment subdividing this long mesh. But in other cases similar long meshes are seen, on close inspection, to be subdivided by an intermediate dissepiment. Meshes subquadrangular.

Horizon and locality.—Five specimens from the Niagara chert, Hamilton, Ontario.

This species has the branches slightly thicker and somewhat more numerous than in *D. retiforme*, which it most resembles. It is therefore a closer form than *retiforme*, the interspaces usually tending to be narrower, or at least not wider than the branches, especially distally, where, on the contrary, in *D. retiforme*, the tendency is for the interspaces to be, relatively to the branches,

FIG. 46.—DICTYONEMA SPENCERI, NEW SPECIES. HOLOTYPE. (SEE ALSO PL. 4, FIG. 1.)

widest, this condition resulting from a tendency of its branches to spread too rapidly for bifurcation to keep pace with the spreading. This of course shows in the number of branches in 25 mm. of width, which at the periphery of *D. retiforme* tends to sink to say 15.

FIG. 47.—DICTYONEMA PARALLELUM, NEW SPECIES. HOLOTYPE. (SEE ALSO PL. 4, FIG. 2.)

Holotype.—Cat. No. 55301, U.S.M.A.

DICTYONEMA PARALLELUM Gurley, new species.

Plate 4, figure 2.

The description by Gurley is as follows:

Polypary originating from a fibrous root; consisting of rigid, wiry, parallel, little-diverging branches, mostly 0.4 mm. wide, but reaching 0.6 mm. in the proximal portion; set 35–40 transversely in 25 mm. Meshes correspondingly narrow, being usually about one-half as wide (but, from slight curving of the branches, may for short distances be as wide) as the branches. Bifurcations not numerous.

Branches connected laterally both by slender, transverse dissepiments, and in places by transverse bands of epidermis; the latter about as wide as the branches. Judging from the few seen, the dissepiments are about 2.5 mm. apart, but this may easily be erroneous, as intermediate ones may have been destroyed. The epidermis over the branches is in several places crossed by transverse lines which probably mark the position of thecæ. These lines are approximately half a millimeter apart (corresponding to about 50 thecæ in 25 mm.).

This species is easily recognizable by the rigid, wiry branches, very thickly set, with correspondingly narrow (nearly obliterated) meshes.

Horizon and locality.—Niagara dolomite, Hamilton, Ontario. Collector, Col. C. C. Grant.

Holotype.—Collection of Walker Museum, University of Chicago, No. 13505.

Genus CALYPTOGRAPTUS Spencer.

Calyptograpsus SPENCER, Canadian Nat., VIII, 1878, p. 458.

Calyptograptus, LAPWORTH, Quart. Journ. Geol. Soc. London, XXXVII, 1881, p. 173.—SPENCER, Proc. Amer. Ass. Adv. Sci., XXXI, 1883, p. 364; Trans. Acad. Sci. St. Louis, IV, 1884, pp. 562, 577; Bull. Mus. Univ. State Missouri, I, No. 1, 1884, p. 27.—MILLER, North Amer. Geol. and Pal., 1889, p. 175.—GURLEY, Journ. Geol., IV, 1896, pp. 93, 308.—RUEDEMANN, New York State Mus., Mem. 11, 1908, p. 163.

Doctor Ruedemann[a] publishes the following on this genus:

Spencer has erected the genus *Calyptograptus* for several species of the Niagaran of Hamilton, Ontario, which are principally distinguished from the similar genera, notably *Dictyonema* and *Callograptus* by the absence of transverse dissepiments. In the first diagnosis it is stated that "in appearance and texture this genus resembles *Dictyonema*, but the branches are [apparently] all independent, not being connected by transverse dissepiments as in that genus and are only united in one mass at the root" [although some of the branches touching each other have occasionally all the appearance of connecting filaments]. This statement has later (1884) been qualified by the same author by the additions here placed in brackets, both of which tend to admit the occasional presence of dissepiments. The absence of the dissepiments and the independence of the branches down to the root, which may be considered as additional diagnostic characters of the genus, find their strictest expression in *C. cyathiformis* the form which is cited as the genotype by Miller [N. Am. Geol. and Pal. 1889, p. 175.]

CALYPTOGRAPTUS CYATHIFORMIS Spencer.

Calyptograptus cyathiformis SPENCER, Canadian Nat., VIII, 1878, pp. 458, 460; Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 578, pl. 3, fig. 3; Bull. Mus. Univ. State Missouri, I, 1884, p. 28, pl. 3, fig. 3.—MILLER, North Amer. Geol. and Pal., 1889, p. 175, fig. 145.—GURLEY, Journ. Geol., 1896, pp. 93, 308.

The following is Doctor Spencer's original description, the bracketed portions being taken from his description published in 1884:

Frond cyathiform, with numerous bifurcating branches, united only at the base, with no lateral processes; the axis consists of a black corneous substance, which is striated longitudinally. The fallen frond has some of the branches overlying each other, forming a coarse [giving somewhat the appearance of an irregular] network. The radicle consists of a well-marked, thick, corneous mass.

The branches are about three-hundredths of an inch in breadth [rather over a millimeter]. The specimen under consideration is most interesting. When

[a] New York State Mus., Memoir 11, 1908, p. 163.

obtained the frond had a general flabellate form with the radicle well marked, having branches radiating to nearly a semicircle; but on trimming the specimen the portion of the stem with radicle was chipped off and revealed the remainder of a beautiful frond which was now shown to be circular—[the frond having been bent partly over in the mud, and having the lower portion covered before the whole was flattened in the sediment] thus proving the funnel-shaped character when living. This fossil is 2½ inches in diameter, and from the base of the root to the top of the branches it measures 1 inch and a half.

It occurs in the Niagara limestone [beneath the chert at the "Jolly Cut"] at Hamilton, Ontario.

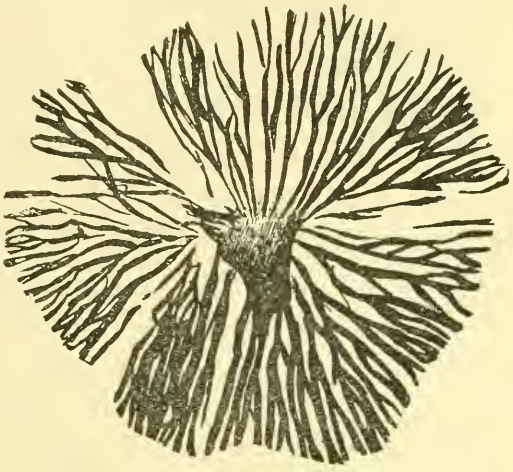


FIG. 48.—CALYPTOGRAPTUS CYATHIFORMIS SPENCER. COPY OF SPENCER'S FIGURE.

The description of 1884 also adds that the branches are divided into two or three small terminations which probably mark the beginning of new branches, and that only one specimen, 6 cm. in diameter, and 4 cm. from the base of the root to the top of the branches, was found. No additional specimens were noted in the more recent collections, so the species is undoubtedly very rare.

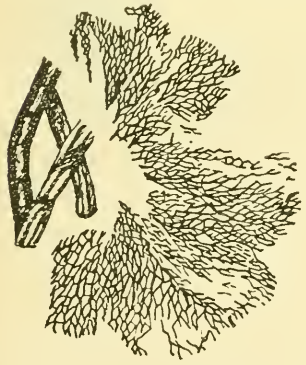


FIG. 49.—CALYPTOGRAPTUS MICRONEMATODES SPENCER. COPY OF SPENCER'S FIGURE.

CALYPTOGRAPTUS MICRONEMATODES Spencer.

Calyptograptus micronematodes SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 579, 588, pl. 3, figs. 4, 4a; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 29, 38, pl. 3, figs. 4, 4a.

Calyptograpsus micronematodes GURLEY, Journ. Geol., IV, 1896, pp. 93, 308.

The original description is as follows:

Frond cyathiform in its growing state, with numerous lateral branches originating from the older stipes. The branches overlie each other, and may be united in some cases, but without true crossbars. The whole frond has an anastomose appearance with irregular rhomboidal interstices. The texture is corneous (though sometimes replaced by pyrites, and the surface is marked with longitudinal striations, which in some places

appear to represent the position of a solid central axis. The terminations of the branches end in two or three points. The branches in this species are very delicate being about a quarter of a millimeter broad, and each branch is not more than from 1 to 2 millimeters in length, before it overlaps or touches the adjacent stipe. The greatest diameter of the frond is not more than 4 cm. Only two or three specimens of this beautiful little frond have been obtained.

FIG. 50.—CALYPTOGRAPTUS MICRONEMATODES SPENCER. PLESIOTYPE IN SPENCER COLLECTION

Formation and locality.—I obtained this species, near the base of the Niagara dolomite, at a quarry just west of the "Jolly-cut-road," Hamilton, Ontario.

A single specimen of this species, represented in figure 50, is at present extant in the Spencer collection. It does not permit of any substantial addition to the above description. The branches show some longitudinal chitinous striæ, but there are no indications of thecæ or dissepiments.

CALYPTOGRAPTUS ? RADIATUS Spencer.

Calyptograptus ? radiatus SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 580, pl. 4, fig. 3; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 30, pl. 4, fig. 3.

Calyptograpsus radiatus GURLEY, Journ. Geol., IV, 1896, pp. 93, 308.

The original description is as follows:

Frond ellipsoid, but cyathiform in its growing state. Numerous delicate branches, with two or three bifurcations, radiating from a common radicle. Some of these touch or overlie each other, but they are quite unconnected. The texture is corneous, with the surface striated and marked with minute depressions or pits, which indicate the former position of the cellule. These depressions are about the fourth of a millimeter in diameter, with an equal space between. The branches are about one-third of a millimeter broad. The greatest diameter of the frond is less than 3 cm. Fragments of this species so resemble species of *Callograptus* that they could not be readily distinguished; but in no species of the latter genus is the conspicuous funnel form apparent.

FIG. 51.—CALYPTOGRAPTUS ? RADIATUS SPENCER. COPY OF SPENCER'S FIGURE.

Formation and locality.—This fossil occurs in the "cherty beds" of the Niagara dolomite at Hamilton, Ontario.

Subgenus RHIZOGRAPTUS Spencer.

Rhizograpsus SPENCER, Canadian Nat., VIII, 1878, p. 460.—GURLEY, Journ. Geol., IV, 1896, pp. 101, 308.

Rhizograptus LAPWORTH, Quart. Journ. Geol. Soc. London, XXXVII, 1881, p. 176.—SPENCER, Proc. Amer. Ass. Adv. Sci., XXXI, 1883, p. 364; Trans. Acad. Sci. St. Louis, IV, 1884, pp. 562, 580; Bull. Mus. Univ. State Missouri, I, 1884, p. 30.—MILLER, North Amer. Geol. and Pal., 1889, p. 202.

Below is given Doctor Spencer's original description, with additional characters, as published by him in 1884, placed in brackets.

Frond flabellate, but cyathiform in growing state; bifurcating branches with dichotomous terminations; [stem terminating in a well-marked bulb]; branches (marked with striæ) more or less reticulated, and united, or overlaid by others.

This genus is established on account of its *bulbous root*, which as yet has been found in no other species of this family. The numerous branches closely overlie each other or are connected in the form of a network without transverse dissepiments, as in *Dictyonema*. Fragments of these somewhat resemble species of *Calyptograptus*, but have a much more [regularly] netted appearance and the branches are much more delicate.

Genotype.—Rhizograptus bulbosus Spencer.

RHIZOGRAPTUS BULBOSUS Spencer.

Rhizograpsus bulbosus Spencer, Canadian Nat., VIII, 1878, p. 460.—Gurley, Journ. Geol., IV, 1896, pp. 101, 308.

Rhizograptus bulbosus Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, p. 580, pl. 4, fig. 4; Bull. Mus. Univ. State Missouri, I, 1884, p. 30, pl. 4, fig. 4.—Miller, North Amer. Geol. and Pal., 1889, p. 202, text fig. 215.

The original description is as follows:

Frond cyathiform in growing state; numerous bifurcating branches overlie each other, or are united at points of contact to form a network, with fine, more or less irregular, rhomboidal interstices. The branches unite at base into a slender axis which terminates in a bulbous root. The branches are usually less than one-fiftieth of an inch wide, and in some specimens short abrupt spinelike branchlets are given off. The texture is corneous. Only a few specimens have been obtained, except in fragments. Frond is about 2 inches high. It was first found by Colonel Grant in the Niagara limestones [near the base of the "chert bed" at the "Jolly-cut"; 1884] at Hamilton, Ontario.

Fig. 52.—Rhizograptus bulbosus Spencer. The type-specimen. (After Spencer.)

Doctor Gurley's notes on this species are as follows:

The description of 1884 adds that the axis is athecaphorous; that the striæ along the branches (which vary in thickness from 0.25 to 0.33 mm.) appear to mark the depressions of the common canal between the original positions of the polypites; that the thecal apertures have an ellipsoid form, and there are about 4 orifices in 1 mm.; and that on the side of the branch opposite the thecæ is a "solid axis."

After a careful examination of *Rhizograptus bulbosus*, in which the pseudomeshwork is well preserved, I can find no criteria to justify its generic distinction from the *Calyptograptus* series, now that the basal "disk" has been found in the latter. While I would provisionally recognize *Rhizograptus* as a subgenus, I can not define it, and I think it probable that further study of large collections will lead to its entire suppression. The only difference I can see is a somewhat different aspect of the branches, which seem of a more rigid texture, more knotty and zigzag-flexuous than any of the *Calyptograptus* species.

Genus ODONTOCAULIS Lapworth.

Odontocaulis LAPWORTH, Quart. Journ. Geol. Soc. London, XXXVII, 1881, p. 175.—POCTA, Syst. Sil. Centre Boheme, VIII, Pt. 1, 1894, p. 171.—RUEDEMANN, New York State Mus., Mem. 11, 1908, p. 172.

Doctor Gurley remarks on *Odontocaulis* as follows:

This genus was thus established by Lapworth for forms which virtually combined two characters: (1) Absence of dissepiments, and (2) a polypiferous stem. Its only distinction from *Dictyonema* and *Callograptus* lay in these two features. But in *O. occidentalis* we find dissepiments *along with* the polypiferous stem. Whence there is now no generic distinction whatever between these two *Odontocaulis* species and the *Callograptus* species at the same horizon, except the single one of the thecæ on the stem. But it is not at all improbable that this is merely a question of better preservation, well-preserved stems being thecate. At least, of the two specimens of *O. occidentalis*, both showing the stem, one shows thecæ perfectly, the other only very obscurely.

Having said this, however, a contingency may properly be noted. May it be possible that *all* the Callograpti at this horizon have thecate stems (in other words, all be referable to *Odontocaulis*)? There is, I think, some ground for such a surmise. As Holm has said for *Dictyonema*, so now for *Callograptus*, the very great geologic range of the genus is a reason for suspecting the validity of the generic reference of the species. May it not then be possible that, compelled as we are for the most part to deal with and to base our species upon fragments of the meshwork, we are confounding two series; say, for illustration,[a] a series lower Ordovician (Calciferous) in distribution, and a series upper Silurian (Niagara) in distribution, both series agreeing in type of meshwork (probably a character of subordinate biologic value), but differing in characters of the base. At present there is nothing to negative such a view. Until we know the proximal portion of the type species (*C. salteri*) this reasoning must, of course, remain purely a possibility. But in a review like the present a clear outlining of future possibilities may be justifiable. Certainly only under some such condition, it seems to me, would *Odontocaulis* stand much chance of ultimate retention. Its provisional retention I think advisable, pending a fuller knowledge of the condition of the base in the remaining Niagara *Callograptus* species. At present its most distinctive characters seem to be: *Polypary arising from a single stem, which is expanded proximally into a "disk," and is thecaphorous along one side; distal branches more or less connected by dissepiments.*

Genotype.—Odontocaulis keepingi Lapworth. Llandovery, of Devils Bridge, Aberystwyth, Cardiganshire.

ODONTOCAULIS GRANTI (Spencer).

Callograptus granti SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum*; Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 571, 572, pl. 1, fig. 10; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 21, 22, pl. 1, fig. 10.—GURLEY, Journ. Geol., IV, 1896, pp. 93, 308.

The original description is as follows:

Frond originating from a single stipe; branches slender, and bifurcating two, three, or four times, and principally originating near the common radicle.

[a] For illustration only, and as a pure surmise of the possibilities of the case.—R. R. Gurley.

In spreading gently above in undulations the branches are more or less parallel and situated closely together, and are connected occasionally with exceeding fine transverse bars. The texture is corneous, with the surface obliquely striated and marked with ellipsoid pits, which in some places indicate the orifices of the cells, of which there were about two for every millimeter of length of branch. The branches are rarely connected by minute crossbars.

FIG. 53.—ODONTOCAULIS GRANTI (SPENCER). A RHABDOSOME AND A BRANCH OF SAME ENLARGED. (AFTER SPENCER.)

The general outline is that of a regular oval form, whose length, in the most perfect specimens, is 3 cm. (besides the common stipe, which extends another centimeter), and breadth, 2 cm. The branches are not more than a quarter of a millimeter broad, while the stipe is about double that thickness.

This exceedingly beautiful frond in general appearance closely resembles *C. salteri* of the Quebec group but somewhat smaller, though there is some variation in the size of this species.

Formation and locality.—This species occurs on the shaly surfaces of the Niagara dolomites at Hamilton, Ontario.

Gurley's notes are as follows:

FIG. 54.—ODONTOCAULIS GRANTI (SPENCER). AN INCOMPLETE RHABDOSOME.

Of this species five specimens, certainly conspecific, were seen. The one figured in text figure 54 differs slightly from Spencer's figure in having the branches somewhat more closely arranged, but in spite of this the identification seems to me almost certain. This specimen has about 50–55 branches in 25 mm. of width. The branches are about 0.25 mm. wide. The dissepiments would seem to have been somewhat numerous; being very delicate, however, most of them are covered or destroyed.

One specimen in the Spencer collection shows the basal stem and the proximal portion of the polypary. Dissepiments are present. The basal stem bears two distinct thecæ at its summit and obscure indications of them below. It is somewhat expanded at its lower end, appearing as though beginning to expand into a "disk." *C. granti* then belongs to the *Odontocaulis* section, whatever may ultimately prove to be the taxonomic rank of that section.

Horizon and locality.—Five specimens: One in Spencer collection, one in New York state collection, and three in U. S. National Museum collection; all five from the Niagara formation, Hamilton, Ontario.

Plesiotype.—Cat. No. 55305, U.S.N.M.

ODONTOCAULIS OBPYRIFORMIS Gurley, new species.

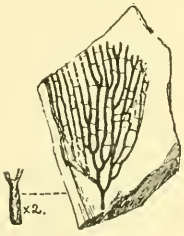


FIG. 55.—ODONTOCAULIS OBPYRIFORMIS, NEW SPECIES. VIEW OF THE HOLOTYPE SHOWING RHABDOSOME AND STEM ENLARGED.

This new species is based on a single specimen in the Spencer collection, and is described by Gurley as follows:

Polypary pyriform, broad end distal, 22 mm. long by 15 mm. broad, arising from a thecate stem extending about 2.5 mm. below the meshwork and there broken off; bearing three thecæ, introverted somewhat as in the Dicranograptidæ. Reticular portion of the polypary,

arising at summit of stems by dichotomy, the branches likewise dichotomizing, the total number of divisions, including the primary, being five or six. In form they are U-shaped. Branches 0.3 mm. wide throughout, except at the extreme base where 4.0 mm. is reached. Peduncle 0.6 mm. wide. Branches set in the proportion of 27 in 25 mm. Dissepiments fairly numerous, being, in some places, as close together as 1 mm.

Horizon and locality.—One specimen from the Niagaran chert, Hamilton, Ontario.

ODONTOCAULIS OCCIDENTALIS Gurley, new species.

Gurley's description and remarks upon this new species are as follows:

Polypary pedunculate-cyathiform showing in both specimens an under layer separated by a "cliff" of rock from and exactly corresponding to the upper layer, as in *Dictyonema*, originating in a stem plainly thecaphorous, but not preserved as far down as the disk, with a virgula (?)[a] 0.2 mm. wide. Stem 0.8 mm. wide to the apices of the thecæ; 0.6 mm. to the bottom of the depressions. Greatest height seen 38 mm., of which the stem takes up 11. Thecæ 40 in 25 mm. Polypary spreading at once unilaterally, almost rectangularly, from the summit of the stem and a little higher up for about 30° to the other side. Branches 0.4 mm. in diameter, flexuous, set rather distantly and quite variably, but mostly about 25 in 25 mm. Dissepiments present, but few and remote. Thecæ visible in few places on branches.

FIG. 56.—ODONTOCAULIS OCCIDENTALIS, NEW SPECIES. A RATHER COMPLETE RHABDOSOME.

Besides the above characters, the figured specimen shows the basal disk, the initial dichotomous division at the summit of the stem, dissepiments, and the cyathiform character of the polypary, the lower layer being visible underlying a "cliff" of rock. On the stem I think I can trace thecæ, but they are too obscure to speak certainly.

Horizon and locality.—Niagara chert, Hamilton, Ontario.

Cotypes.—Cat. No. 55306, U.S.N.M.; Walker Museum, University of Chicago, No. 13514.

Genus CYCLOGRAPTUS Spencer.

Cyclograptus SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum*; Proc. Amer. Assoc. Adv. Sci., XXXI, 1883, p. 365; Trans. Acad. Sci. St. Louis, IV, 1884, pp. 563, 592; Bull. Mus. Univ. State Missouri, I, 1884, p. 42.—MILLER, North Amer. Geol. and Pal., 1889, p. 182.—GURLEY, Journ. Geol., IV, 1896, pp. 94, 309.—RUEDEMANN, New York State Mus., Mem. 11, 1908, p. 182.

[a] It certainly bears some appearance of being a true virgula. Were the stem alone and the rock stated to be Lower Silurian, no one would hesitate to pronounce it a virgula. But as this is the only case in these Upper Silurian Dendroidea where I have seen any *close* resemblance to a virgula, doubt is but natural.—R. R. Gurley.

Spencer's description of this genus is as follows:

In this genus, the frond consists of a circular disk which was probably cup-shaped in its growing form, though flattened in a concave manner in the rock. From the radicle many stipes radiate through the noncelluliferous disk to its margin, and thence in a free manner to some distance beyond. The whole frond resembles a solid wheel, where the radiating spokes extend from the center regularly to beyond the circumference. The branches beyond the disk are celluliferous. The stipes have a central solid axis. The substance is highly corneous, though in some places replaced by pyrites.

Doctor Ruedemann has reviewed this genus in his monograph, to which the reader is referred for comparisons between this and related genera.

Genotype.—Cyclograptus rotadentatus Spencer.

CYCLOGRAPTUS ROTADENTATUS Spencer.

Cyclograptus rotadentatus SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 565, 592, 593, pl. 6, figs. 6, 6a; Bull. Mus. Univ. State Missouri, I, 1884, pp. 15, 42, 43, pl. 6, figs. 6, 6a.—MILLER, North Amer. Geol. and Pal., 1889, p. 182, text fig. 162.—GURLEY, Journ. Geol., IV, 1896, pp. 94, 309.—RUEDEMANN, New York State Mus., Mem. 11, 1908, p. 184, pl. 2, fig. 5.

Doctor Spencer's original description is given below:

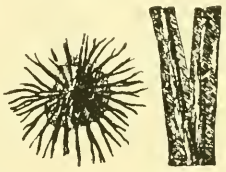


FIG. 57.—CYCLOGRAPTUS ROTADENTATUS SPENCER. COPY OF SPENCER'S FIGURE.

Frond circular, with numerous stipes radiating from a common center and projecting like a toothed wheel beyond the margin of a noncelluliferous disk. The frond was probably cup-shaped when growing, with the stipes projecting upward like a row of spines or tentacles, but in the rock the fossil is flattened and slightly convex. The stipes originate in the center and are connected about half their length by their continuous noncelluliferous membrane. Each stipes after passing beyond their solid disk divide into two branches about halfway between their extremities and the margin of the disk. The branches or stipes are traversed by a central cylindrical, smooth, solid axis surrounded by their common canal, which is sometimes only represented by a central depression or elevation, but occasionally its form is well preserved. The rarely indicated cell openings are represented by minute oval depressions in the substance. The texture is highly corneous (or replaced by pyrites).

FIG. 58.—CYCLOGRAPTUS ROTADENTATUS SPENCER. A LARGE SPECIMEN FROM THE CLINTON GROUP, CLINTON, N. Y. (AFTER RUEDEMANN).

The diameter of the frond is 2 cm., and of the disk 1 cm.; the radiating branches extend half a centimeter beyond the disk, and number between 25 and 30, but, as each is divided, the frond is surrounded by about 60 points. The branches (both through the disk and free portion) are rather over half a millimeter broad, but the terminals are scarcely more than half that thickness and end in sharp points.

Formation and locality.—This perfect little species was found in the dolomite of the Niagara formation proper, near the base of the series, at the quarry just west of the "Jolly-cut" road at Hamilton, Ontario.

Doctor Ruedemann has recently figured a specimen referred to this species, found in the upper part of the Clinton, at Clinton, N. Y. (See text, fig. 58.) Except in the matter of size, this example does not differ from the original type.

Genus INOCAULIS Hall.

Inocaulis Hall, Amer. Journ. Sci. (2), XI, 1851, p. 401; Nat. Hist. New York, Pal., II, 1852, p. 176; 20th Rep. New York State Cab. Hist., 1868, p. 218 (rev. ed., 1868 [1870], p. 252).—Nicholson, Mon. Brit. Graptolitidæ, 1872, p. 131.—Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 562, 583; Bull. Mus. Univ. State Missouri, I, 1884, p. 33.—Miller, North Amer. Geol. and Pal., 1889, p. 193.—James, Journ. Cincinnati Soc. Nat. Hist., XIV, Pt. 2, 1892, p. 161.—Pocta, Syst. Sil. Centre Boheme, VIII, Pt. 1, 1894, p. 197.—Elles and Wood, Mon. Brit. Graptolites, Pal. Soc., 1903, p. xxxiv.—Ruedemann, New York State Mus., Mem. 11, 1908, p. 185.

Hall's original description of this genus is as follows:

A plantlike, corneous coral, with numerous bifurcating branches; structure fibrous or plumose.

The texture of this coral is similar to the Graptolites, a black scaly crust or film being all that remains of the substance. From the specimens examined, it appears to have grown in groups, with rounded or flattened stems, which are dichotomous above and more or less spreading. The structure is too peculiar to be mistaken or to be referred to any established genus.

Genotype.—*Inocaulis plumulosus* Hall. Niagaran of New York and Canada.

The characters of both the genus and its type species have been discussed by Doctor Ruedemann in his monograph.

INOCAULIS PLUMULOSUS Hall.

"———————" ? Hall, Rep. Surv. 4th Geol. Dist. New York, 1843, p. 116, fig. 1.

Inocaulis plumulosa Hall, Nat. Hist. New York, Pal. II, 1852, p. 176, pl. 40G, figs. 2a, 2b; Geol. Surv. Canada, Can. Org. Rem., Decade 2, 1865, p. 18, fig. 26; 20th Rep. New York State Cab. Hist., 1868, p. 185, text fig. 28 (rev. ed., 1868 [1870], p. 215, text fig. 28).—Nicholson, Mon. Brit. Graptolitidæ, 1872, p. 132, text fig. 73.

Inocaulis plumulosus Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, p. 584, pl. 5, fig. 1; Bull. Mus. Univ. State Missouri, I, 1884, p. 34, pl. 5, fig. 1.—Miller, North Amer. Geol. and Pal., 1889, p. 193, text fig. 183.—Ruedemann, New York State Mus., Mem. 11, 1908, p. 188, pl. 2, fig. 4; pl. 7, figs. 1, 2.

Doctor Gurley's manuscript contains an elaborate description of this species, but the description and remarks published by Doctor Ruedemann are more to the point and are reproduced below:

Hall has given the following diagnosis of this species:

Stems flattened, dichotomous; structure fibrous or plumulose, apparently composed of imbricating elongated scales or fibers which spread equally on all sides.

This coral is not abundant, though small fragments are frequently seen in the slab. It is very often replaced by iron pyrites, and where the surface

FIG. 59.—INOCAULIS PLUMULOSUS HALL. A RATHER COMPLETE RHABDOSOME.

is exposed to weathering, the fossil soon disappears so that it is only on freshly fractured surfaces that the structure is preserved.

It is cited as occurring in the "Niagara shale at Lockport, Rochester, and other places."

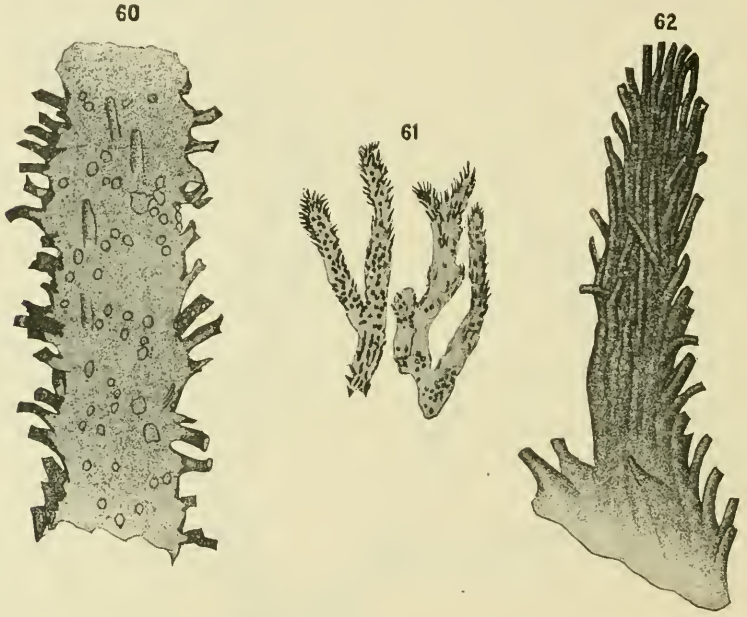
Spencer has recorded the form from the Niagaran limestone at Hamilton, Ontario.

Gurley, in his manuscript, adds to the descriptions of Hall and Spencer in the following note:

> Two specimens from the Niagara formation, at Hamilton, Ontario, are figured, showing the blunt toothlike bodies and the apparently dentate margin. While the appearance much resembles thecæ, it is impossible to make a positive statement on the material available.

From a fairly large series of good specimens we derive the following data on this important species:

The rhabdosome is arborescent in form; the branches divide dichotomously at irregular intervals, forming initial angles of 50°–60° but becoming later subparallel; of large dimensions (maximal length of largest fragment observed 14 cm., width of another 17 cm.), the stem near base 5 mm. thick, the branches quite uniformly 3 mm. The branches diminish hardly toward the distal ex-



FIGS. 60–62.—INOCAULIS PLUMULOSUS HALL. 60, PORTION OF A BRANCH, × 5; 61, DISTAL PORTION OF BRANCHES SHOWING TUBULAR BRANCHLETS AND IMPRESSIONS OF THEIR APERTURES; 62, TERMINAL PORTION OF A BRANCH.

tremities which are bluntly rounded. The stem is apparently smooth, the branches are thickly set with short tubular processes which project about 1 mm. from the body of the branch, are of uniform width, directed upward and distally slightly bent backward and number, counted along the margin, about 14 in 10 mm. On specimens where the body of the branch has weathered away, exposing the apertures of the reverse side, they are seen to be distributed about equally over the whole branch, being approximately arranged in quincunx and numbering about five in the width of the stem. At the extremities of the branch they form dense tufts.

Remarks.—The general habitus of *I. plumulosa* can be best described by a comparison with a Lepidodendron or a Lycopodium; it not only resembles these plants in the mode of its branching and the uniformly wide, blunt ending branches, but also in their scaly appearance.

Hall's original and later improved figures give a good conception of the general appearance of the form. A more complete specimen from the Lockport

limestone at Hamilton is here reproduced in text figure 93 [59] by a pen drawing made under Gurley's supervision. In Plate II, figure 4 [text fig. 61] a portion of the same specimen which is partly weathered has been refigured to show the thecæ. Where in unweathered specimens the perisark is partly broken away [as in text fig. 60], the circular sections of the composing tubes can be seen and the whole branch is found to be composed of apparently equal tubes.

The rhabdosome, when more complete than in the specimens hitherto mentioned, forms a dense mass of overlapping branches, which on account of the frequent dichotomies and later reapproachments of the branches assumes to some extent the aspect of a huge Desmograptus.

We have been unable to see in any of our or Spencer's rhabdosomes the central axis which he asserts to have observed in a number of specimens, and we doubt, from the general structure of this form, that such a thing as a central axis existed.

Horizon and locality.—The type is from the Niagara shale of New York, and the specimen here figured (text fig. 59) from the same horizon at Hamilton, Ontario.

Plesiotype.—Cat. No. 54281, U.S.N.M.

INOCAULIS RAMULOSUS Spencer.

Inocaulis ramulosa SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum.*
Inocaulis ramulosus SPENCER, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 565, 588, 589, pl. 6, fig. 1; Bull. Mus. Univ. State Missouri, I, 1884, pp. 15, 38, 39, pl. 6, fig. 1.— GURLEY, Journ. Geol., IV, 1896, pp. 99, 309.

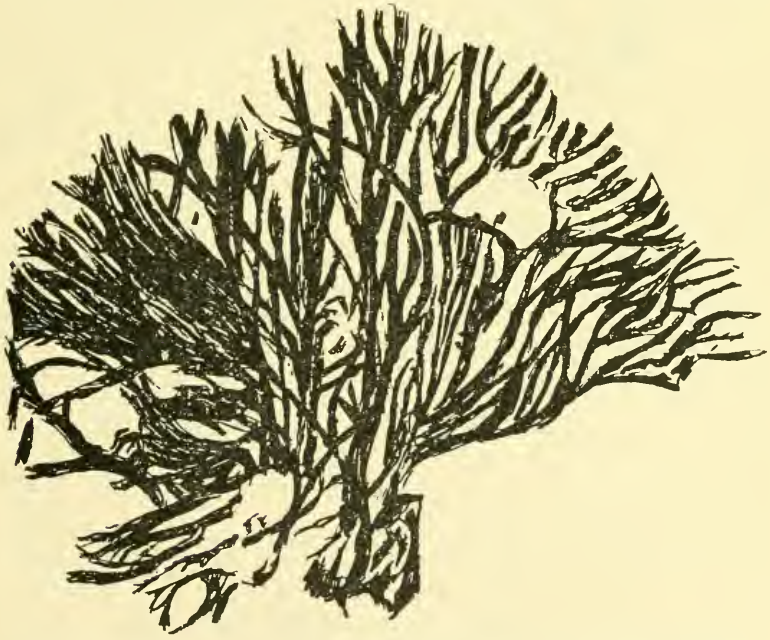


FIG. 63.—INOCAULIS RAMULOSUS SPENCER. COPY OF SPENCER'S FIGURE.

The original description by Spencer is as follows:

Frond consisting of numerous flattened bifurcating branches, originating in and radiating from a common radicle, composed of solid chitinous matter;

branches averaging 2 mm. in breadth for the larger and 1 mm. for the smaller, toward the margin of the frond, where the branchlets end in two (sometimes three) extensions of unequal thickness. Texture corneous, with the surface composed of scaly fibers. Extending longitudinally through the stipes are central or subcentral elevations (sometimes depressions), indicating a solid central axis.

This species is described on two specimens, one of which shows the origin and base of the radiating branches, and the other the general frond, although the radicle is concealed. The extreme width of the typical specimen is 14 cm., and the height 8 cm.

FIG. 64.—INOCAULIS RAMULOSUS SPENCER. SPECIMEN IN U. S. NATIONAL MUSEUM.

In general form this species differs from *I. plumulosus* in that the branches are more slender and rise regularly and more abundantly from the sides of the main stipes, which radiate from a common origin and do not consist of groups of individual fronds. The radicle appears to have been attached to some rocky surface in the sea, and not to have grown on some muddy bottom. The cell-bearing stipes appear to have had a common canal, through the center of which was a central solid axis, as is also indicated in *I. cervicornis*.

Formation and locality.—These specimens were obtained in the shaly dolomites, below the "chert beds" of the Niagara formation at the "Jolly-cut," Hamilton, Ontario.

Doctor Gurley's notes are as follows:

Polypary, in the single specimen seen, rising from a stem which gives off, in the proximal half of the portion visible, very few branches which, moreover, do not rebranch into a bushlike form, the bushlike branching occurring only in the distal half of the polypary. The only proximal branch distinctly seen bears a close spike of straplike processes (abortive branchlets?). Distally the polypary branches out bushlike, the main branches about 1 mm. thick. At or near the summit the branches subdivide into 2 or 3, usually unequal or subequal, terminal twiglets. The sides of the branches are usually slightly fringed; the processes hairlike, few and remote.

The stems of this species remotely resemble those of *Acanthograptus granti*, but they are much more remotely and much more finely fringed, and in its ensemble this species has the branches less rigid and parallel than has *A. granti*.

Horizon and locality.—Niagaran (Lockport), Hamilton, Ontario.
Plesiotype.—Cat. No. 55314, U.S.N.M.

INOCAULIS CERVICORNIS Spencer.

Inocaulis cervicornis Spencer, Canadian Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 565, 587, pl. 5, fig. 5; Bull. Mus. Univ. State Missouri, I, 1884, pp. 15, 37, pl. 5.—Gurley, Journ. Geol., IV, 1896, pp. 99, 308.

The original description is as follows:

Frond consisting of stipes having a common origin and rising above into a few stout, widely extended, bifurcating branches, averaging from 1.5 to 2 mm. in breadth, and terminating in dichotomous points of equal thickness; texture corneous, with a striated surface.

Fig. 65.—Inocaulis cervicornis Spencer. Copy of Spencer's figure.

Owing to the striations the appearance of the surface is that of rough scales or fibers, somewhat resembling the exterior portion of *I. plumulosus*. In the growing state the branches appear to have been strengthened by longitudinal fibers—solid corrugations—and the cells to have been arranged vertically between them. A portion of the branches show a solid central axis, with a common canal surrounding it. The general arrangement of the branches resembles that of the horns of the American elk.

The typical specimen consists of 6 principal stipes, each about 3 centimeters long, with only a few branches. These stipes are united by a common runner (in the botanical sense), so that the whole organism is 5 centimeters broad and 3 centimeters high.

Formation and locality.—This rare and beautiful species occurs in the shaly dolomites of the Blue Building beds of the Niagara formation at the "Jolly-cut," Hamilton, Ontario.

A single specimen in the collection of the U. S. National Museum is known, but presents no additional information.

Fig. 66.—Inocaulis phycoides Spencer. The type-specimen and a branch enlarged.

INOCAULIS PHYCOIDES Spencer.

Inocaulis phycoides Spencer, Canadian Nat., X, 1882, p. 165, *nomen nudum.*

Inocaulis phycoides Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 565, 588, pl. 5, figs. 6, 7; Bull. Mus. Univ. State Missouri, I, 1884, pp. 15, 38, pl. 5, figs. 6, 7.—Gurley, Journ. Geol., IV, 1896, pp. 99, 309.

The original description is as follows:

Stem flattened and from 2 to 3 mm. broad; branches fastigiate, and originating on both sides of the principal stipe at frequent irregular intervals, and dividing near their terminations into two stout branchlets (from $\frac{3}{4}$ to $1\frac{1}{2}$ cm.

long), each ending in dichotomous free points. Texture corneous, with a surface apparently composed of scaly fibers.

Of this species the fossils are not very well preserved. There is some indication of a central axis. This species is easily distinguished from *I. plumulosus* by the close, regularly arranged, parallel branches from each side of the principal stipes and by their terminal branches. The fronds appear to have grown in groups, but whether they are connected at the base or not is unknown. If not connected, the individual fronds (in the specimens under consideration) are about 4 cm. high and 3 broad, with from 3 to 5 principal branches on either side of the central stipe (the branches are more numerous on one side than the other). The character of the cellules is unknown.

Formation and locality.—Inocaulis phycoides occurs in the dolomitic limestones of the Niagara formation at the "Jolly-cut" quarries, Hamilton, Ontario.

A specimen doubtfully referred to this species occurs in the National Museum collections, but shows nothing in addition to the above.

INOCAULIS DIFFUSUS Spencer.

Inocaulis diffusa SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum.*
Inocaulis diffusus SPENCER, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 565, 586, 587, pl. 5, fig. 4; Bull. Mus. Univ. State Missouri, I, 1884, pp. 15, 36, 37, pl. 5, fig. 4.—GURLEY, Journ. Geol., IV, 1896, pp. 99, 308.

This species was described by Spencer as follows:

Frond originating in a single stipe at base, and rising above in numerous widely extended branches averaging about a millimeter in breadth, with dichotomous terminations; branchlets originating more frequently on one side than on the other. Texture corneous, with surface more or less regularly striated, leaving in some places small oval impressions (probably the orifices of the cellules).

FIG. 67.—INOCAULIS DIFFUSUS SPENCER. COPY OF SPENCER'S FIGURE.

Of this species I have seen only one good specimen (and two inferior fragments which probably belong here). The frond is 6 cm. high and of still greater breadth. One of the branchlets of the dichotomous termination is much more slender than the other (a sort of lateral pustule), indicating probably the commencement of the growth of a new branch.

The general form of this species is like *I. bellus* (Hall and Whitfield), but it is much larger in size, having more diffused branches, with an entire absence of prong-like processes from its sides.

Formation and locality.—The type of this species was obtained by Colonel Grant, near the base of the "cherty bed" at the "Jolly-cut," Hamilton, Ontario, in the Niagara dolomite.

Doctor Gurley has the following notes based upon a specimen (text fig. 68) referred to this species by him:

The (fragmentary) polypary consists of a main stem the sides of which are beset with spinular processes similar to those found in *Inocaulis*. The branching is at an acute angle (about 35°). The main stem is about 0.8 mm. wide. The spinular processes are 0.5–0.6 mm. apart (too few are visible to state the number in 25 mm.). Besides these processes two others of a different character, 1 mm. long, are visible. They belong to the class regarded by Spencer as rudimentary branchlets. Both stem and branches are longitudinally striate, many distinct chitinous fibers being visible.

FIG. 68.—INOCAULIS DIFFUSUS SPENCER. SPECIMEN DESCRIBED BY GURLEY.

Horizon and locality.—Niagara limestone and chert, Hamilton, Ontario.

Plesiotype.—Cat. No. 55315, U.S.N.M.

INOCAULIS DIFFUSUS CRASSIRAMUS Gurley, new variety.

Plate 5, figure 2.

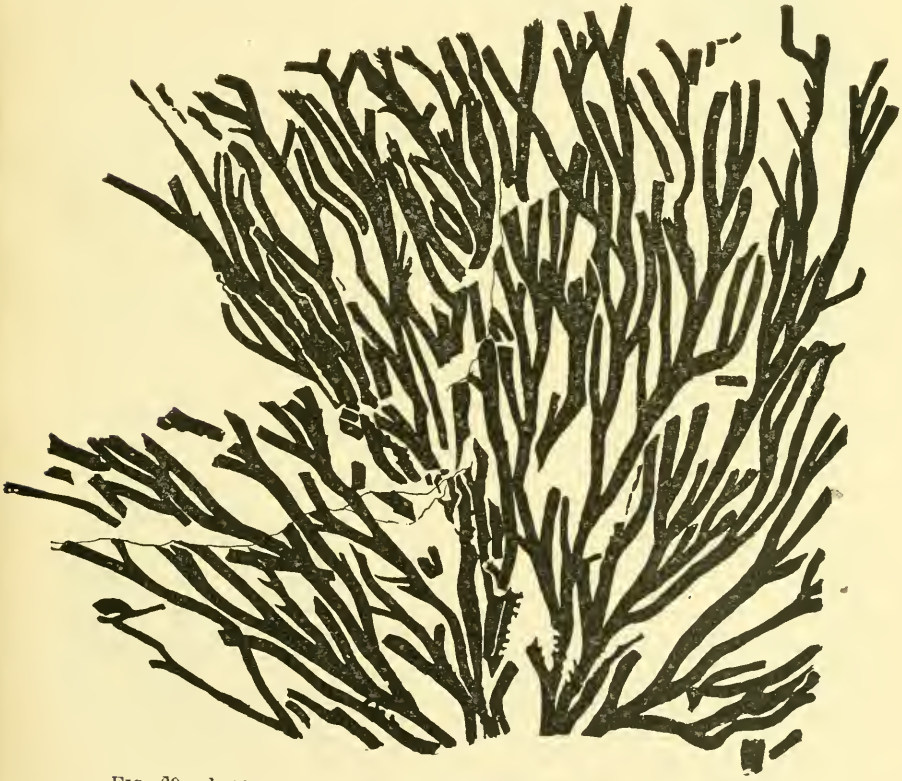


FIG. 69.—INOCAULIS DIFFUSUS CRASSIRAMUS, NEW VARIETY. HOLOTYPE.

One specimen, which, judging from Spencer's figure and description, seems to have the habit of *I. diffusus*, is described by Gurley as a variety as follows:

Polypary consisting of numerous branches not widely radiating, 2 mm. wide *ad max.;* the smallest seen about 1 mm. wide; longitudinally striated by very

fine fibers; showing on the margins some blunt triangular processes, about 0.5 mm. wide and projecting about 0.5 mm. from the stem and about 1 mm. apart. From the present material it would seem as though these processes form a somewhat less prominent feature than in *I. diffusus* and in *I. walkeri*, but this is somewhat doubtful.

The principal difference between this variety and *I. diffusus* proper is the considerably greater thickness of the branches and the lesser prominence of the lateral blunt spines. The latter feature, however, may be a condition of preservation, and the former distinction may possibly be obliterated by a larger series of specimens.

Horizon and locality.—Niagara dolomite (blue building bed), Hamilton, Ontario.

Holotype.—Walker Museum, University of Chicago, No. 13507.

FIG. 70.—INOCAULIS CONGREGATUS, NEW SPECIES. HOLOTYPE.

INOCAULIS CONGREGATUS Gurley, new species.

A single specimen in the collection of the Walker Museum is the basis of this species, described by Gurley as follows:

Polypary consisting of a number (about 8 in the type-specimen) of approximated and parallel stems, which are set 20 in 25 mm. transversely, and are simple for about 25 mm. Several bifurcate at this level; the central ones, however, bifurcate about 10 mm. higher up. Thickness of main stem about 1–1.2 mm.; of branches nearly the same (about 1 mm.). Thecæ obscure, the margins of the branches obscurely subserrate.

Horizon and locality.—Niagaran formation, Hamilton, Ontario.

Holotype.—Walker Museum, University of Chicago, No. 13508.

INOCAULIS ? STRICTUS Gurley, new species.

Plate 2, figure 6.

The description by Gurley is as follows:

Branches rigid, not spreading, but upright and rather straight, bifurcating at a comparatively small angle (about 45°), diminishing in width from 2 mm. at the proximal end of the fragment to 1.5 (rarely to 1) mm. at the distal. Margins generally smooth, in one or two places subserrate. Successive bifurcations rather frequent (distant 5 to 10 mm.).

FIG. 71.—INOCAULIS? STRICTUS, NEW SPECIES. HOLOTYPE. (SEE ALSO PL. 2, FIG. 6.)

Horizon and locality.—Niagara chert, Hamilton, Ontario; one specimen (the type) in the Spencer collection, one specimen in Grant collection.

INOCAULIS VEGETABILIS Gurley, new species.

Plate 5, figure 1.

Gurley describes this species as follows:

A specimen in the New York State collection has the mode of growth characterizing *I. phycoides*, but is *very* much stouter in every way, the thickness of the stem and main branches reaching 6 or even 7 mm. and the terminal branches measuring 3 and 4 mm. Still it is not absolutely impossible that the difference may be merely one of age or distance from the point of origin of the polypary, but there is at present nothing to show that this is the case.

The substance is in this case preserved in places, and forms a thick, coal-black film with longitudinal striations and furrowing corresponding to fibers and bands. No thecæ are visible.

Horizon and locality.—Niagaran (Lockport), Hamilton, Ontario.

Holotype.—New York State collection.

INOCAULIS ? THALLOSUS Gurley, new species.

Plate 2, figure 5.

Gurley describes this species as follows:

Polypary 15 mm. long and 9 mm. in extreme breadth, consisting of a main stem about 1 mm. thick, from which proceed laterally at a little less than a right angle, branches about 0.6 mm. wide and about 5 mm. or less long. The branches bifurcate about 1.5 mm. from the stem, and farther on redivide.

Only a single specimen (obverse and reverse) of this species was seen. The species simply show as a stain (but a well-outlined stain) on the rock, with little or no evidence of graptolite structure. It is therefore possible that this species does not belong to the graptolites, but at any rate it seems to be new and is a part of the fauna.

Horizon and locality.—Niagara limestone at base of chert, Hamilton, Ontario.

Holotype.—Cat. No. 55316, U.S.N.M. The reverse is in the Spencer collection.

Genus ACANTHOGRAPTUS Spencer.

Acanthograpsus Spencer, Canadian Nat., VIII, 1878, p. 461.

Acanthograptus Lapworth, Quart. Journ. Geol. Soc. London, XXXVII, 1881, p. 174.—Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 562, 581; Bull. Mus. Univ. State Missouri, I, 1884, p. 31.—Miller, North Amer. Geol. and Pal., 1889, p. 170.—Ruedemann, New York State Mus., Mem. 11, 1908, p. 191.

The original description is as follows:

Frond shrublike, consisting of thick branches, principally rising from near the base, with little divergence and some bifurcations. One side of the branches is furnished with prominent spines or dentacles, which appear to mark the cell-apertures. Texture corneous and indistinctly striated. This

generic form resembles *Dendrograpsus*, but it is stronger and more bushy than species of that genus, and has conspicuous spines indicating a different cell structure [in whose axils the thecæ were probably situated; 1884].

Gurley adds in his manuscript to Spencer's definition of the genus:

This is apparently a good genus, including several species which present a very similar facies, principally in the plumulose branches with a tendency to a 2- or 3-spicate termination. But if this genus be altogether distinct from *Inocaulis* (a point on which at present I do not feel positive), it is certainly here that Spencer's *Inocaulis walkeri* belongs.

Genotype.—*Acanthograptus granti* Spencer. Niagaran (Lockport), Hamilton, Ontario.

ACANTHOGRAPTUS GRANTI Spencer.

Plate 2, figure 1; Plate 3, figure 4.

Acanthograpsus granti Spencer, Canadian Nat., VIII, 1878, pp. 458, 461, 462.
Acanthograptus granti Spencer, Canadian Nat., X, 1882, p. 165; Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 582, pl. 4, fig. 5; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 32, pl. 4, fig. 5.—Gurley, Journ. Geol., IV, 1896, pp. 92, 308.

Fig. 72.—Acanthograptus granti Spencer. Copy of Spencer's figure.

The original description is as follows:

Frond shrublike, with thick branches principally originating near the base. Some of the branches are bifurcated and have the ends dichotomous; cell apertures on one side only, and indicated by prominent spines which appear to be placed below them. The branches are sometimes the sixteenth of an inch broad, with spines in some places projecting the twenty-fourth of an inch and ending abruptly.

The larger fronds do not exceed two inches in height and sometimes have the same width.

This species was first obtained [in the Niagaran dolomites; 1884] at Hamilton, Ontario, by Colonel Grant.

The description of 1884 adds the following data:

Surface longitudinally striated. Occasionally there are rudimentary denticles appearing also on the opposite side of the branch as well as on that marked with the regular spinelike projections, of which there are 6 or 7 in the length of a centimeter of the stipe, which is characterized by obscure indications of a solid central axis. The branches average a millimeter in breadth, and the spines are sometimes a millimeter long, which in some places extend into the material of the stipe to its center. The flattened frond is usually 4 or 5 cm. high and about 4 wide, and consist of 15 or 20 branches at half its height, which are somewhat more numerous at the summit, owing to occasional bifurcations. The whole frond originates from a common radicle.

The best preserved graptolites that are found at Hamilton occur on the shaly surface of the limestone, but this species is only found in the highly crystalline rock, and consequently, although the general form of frond is well preserved and very beautiful, the detailed structure is not shown as well as in the forms that are found in the more perishable shaly rocks.

Gurley adds the following:

This species is easily recognizable among the now known *Acanthograptus* species by the very heavy branches, which very generally measure 1 mm. or a little more, though occasionally one as narrow as 0.8 mm. is seen. As regards

FIGS. 73, 74.—ACANTHOGRAPTUS GRANTI SPENCER. 73, DISTAL PORTION OF RHABDOSOME, × 5; 74, A NEARLY PERFECT RHABDOSOME. (AFTER RUEDEMANN.)

number, they are set rather irregularly, but usually there are about 15 in 25 mm. of width. The specimens show no evidence of thecæ or of a virgula.

Plesiotypes.—Cat. No. 55310, U.S.N.M. Specimen figured on Plate 2, figure 1, in Spencer collection.

ACANTHOGRAPTUS WALKERI (Spencer).

Inocaulis walkeri SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 585, 586, pl. 5, fig. 2; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 35, 36, pl. 5, fig. 2.—GURLEY, Journ. Geol., IV, 1896, pp. 99, 309.

Acanthograptus walkeri RUEDEMANN, New York State Mus., Mem. 11, 1908, p. 194, pl. 6, figs. 1, 2; pl. 7, fig. 4, text figs., 97, 98.

Spencer's diagnosis reads:

Frond strong, with spreading branches, the margin having a plumulose appearance; structure corneous, with a central axis, and the surface covered with minute points representing the cell-apertures.

This frond somewhat resembles *I. plumulosus*, but it is slighter, and the branches (not exceeding 1.5 mm. in thickness) are much more numerous and proceed from a single stipe. The type specimen has a height of 8 and a breadth of 6 cm.

Formation and locality.—This species occurs in the Niagara limestones at Hamilton, Ontario.

Doctor Gurley describes the species as follows:

Polypary of general dendroid aspect; main branches mostly 1–1.5 mm. thick, a width of 2 mm. being only seen once, immediately below a bifurcation. Branching not very regular. Usually at the proximal end several branches

FIG. 75.—ACANTHOGRAPTUS WALKERI (SPENCER). COPY OF SPENCER'S FIGURE.

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FIGS. 76, 77.—ACANTHOGRAPTUS WALKERI (SPENCER). TWO FRAGMENTARY SPECIMENS.

are somewhat clustered, and diverge thence radiatingly. On one specimen, which I hardly feel able to separate, the branching is rather more from a main axis. The branches, especially the main ones, are thickly beset (spinose-shaggy) with the long, blunt, obliquely upward-directed denticles, which are about 25 in the space of 25 mm. They differ much in appearance in different parts of the polypary, if, indeed, there are not more than one kind of them. Sometimes on the main stem they are blunter (about 1.0 mm. long and 0.75 mm. wide at base), while on the branches and branchlets they are less blunt. But on the main stem and principal branches longer, narrower, and less rigid and regular and more hairy root-like processes occur.

This species can be told by the distinct and numerous "denticles" on both sides of stem and branches, finer and less blunt dentate than in *A. granti*.

Horizon and locality.—Niagaran (Lockport), Hamilton, Ontario.
Plesiotypes.—Cat. Nos. 54277, 55317, U.S.N.M.

FIGS. 78–80.—ACANTHOGRAPTUS WALKERI (SPENCER). 78, BRANCHES SHOWING BRANCHLETS AND THECAL APERTURE, × 5; 79, A SPECIMEN NATURAL SIZE, ROCHESTER SHALE, NEW YORK; 80, FRAGMENT OF BRANCH, × 5, ROCHESTER SHALE, NEW YORK. (79 AND 80 ARE AFTER RUEDEMANN.)

ACANTHOGRAPTUS PULCHER Spencer.

Plate 4, figure 5.

Acanthograptus pulcher SPENCER, Canadian Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 564, 582, 583, pl. 4, fig. 6; Bull. Mus. Univ. State Missouri, I, 1884, pp. 14, 32, 33, pl. 4, fig. 6.—MILLER, North Amer. Geol. and Pal., 1889, p. 170, fig. 128.—GURLEY, Journ. Geol., IV, 1896, pp. 92, 308.

The original description is as follows:

This frond is broadly flabellate, but was possibly cyathiform in its growing state. Very numerous branches (with few principal subdivisions) arise from a common radicle and extend in an entirely free manner to the even and more or less circular margin of the frond. Along both sides of the branches many short rudimentary branchlets arise. Besides these, there are numerous spinelike processes, which possibly indicate the position of the cellules. The texture is corneous, with the surface striated, and in some places, where removed, there are indications of a lateral solid axis. From the center of the radicle the branches extend a distance of about 2½ mm. [centimeters. R. R. G.] to the margin of the ground [frond. R. R. G.], or the diameter is about 5 mm. [centimeters. R. R. G.]. The branches are half a millimeter thick. The rudimentary branchlets, irregularly situated, are seldom more than 2 mm. long, and are stout, while the spinelike processes have a length of half a millimeter, and are about the same distances apart, being very slender.

The branches of this exceedingly beautiful frond (as I have only one complete specimen) appear to have occupied a semicircular position when alive, but in

compression has so fallen as to extend nearly in the form of a circle. Though it resembles somewhat *Callograptus niagarensis*, yet the numerous rudimentary branchlets and spinelike processes distinguish it from that species.

Formation and locality.—This species is found in the "chert-beds" of the Niagara formation at Hamilton, Ontario. The best specimen was obtained from Mr. Edward McLaughlin, of Hamilton.

Gurley's notes on this species follow:

To this species I have referred, in all, sixteen specimens, several of the more fragmentary ones with some doubt. One specimen (Pl. 4, fig. 5, text fig. 82) shows the base, and may be described as follows:

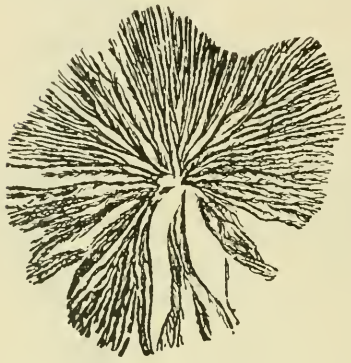

FIG. 81.—ACANTHOGRAPTUS PULCHER SPENCER. COPY OF SPENCER'S FIGURE.

Polypary (in this specimen) semicircular-flabelliform, originating in, and sessile upon, a transversely extended, apparently thick, fibrous, or discoid base of a black carbonaceous texture. From the base arise about three main branches, which bifurcate and rebifurcate in their course toward the periphery, the resulting somewhat wavy branches running nearly straight out to the periphery, where they seem to terminate in two or several twigs or spikelets. Along their course their sides are beset with "rudimentary branchlets," etc., whose length may reach 1 mm. In this species, however, these lateral fringing processes are fine, giving the branches a feathered appearance. They never reach the thickness and remoteness of those seen in *A. walkeri*. The usual width of the branches is 0.4 mm., but some reach 0.5 mm. About 40 branches occur in 25 mm. of width, the interspaces thus being quite narrow. Only two thecæ are visible. These are 0.4 mm. apart (corresponding to about 60 in 25 mm.). Indications of dissepiments are not wanting (some structures very much like them are visible), and although not entirely willing on strength of the present material, I may say that I incline very strongly to doubt their asserted absence in any of these genera, and also that in my opinion there is hardly a more dubious character than "absence of dissepiments." For the assertion of such a condition the material must be absolutely irreproachable, as of all the structures in the polypary the dissepiments, being the most delicate, are the first to disappear.

FIGS. 82, 83.—ACANTHOGRAPTUS PULCHER SPENCER. 82, SPECIMEN PRESERVING BASE. (SEE ALSO PL. 4, FIG. 5); 83, LESS COMPLETE RHABDOSOME.

There can, I think, be no doubt that the present form is Spencer's species. Both as a diagnosis by exclusion, and by its general agreement with his description and figure, its identity is satisfactorily made out.

Horizon and locality.—Niagara chert and glaciated chert, Hamilton, Ontario.

Plesiotypes.—Cat. No. 55307, U.S.N.M.

ACANTHOGRAPTUS CHAETOPHORUS Gurley, new species.

Plate 3, figure 5.

Gurley's description is as follows:

Polypary consisting of several main stems which may reach a thickness of 0.4 mm.; but principally characterized by very numerous, excessively fine, hair-like, more or less tufted fibers which fringe the sides of the stems and (?) also arise freely from the (invisible) base. Thecæ appear to be present, but are indistinct.

This species unquestionably finds its nearest affinity in *Acanthograptus*. It can hardly be a *Dendrograptus*, if that term be limited to forms taking origin from a single stem, as the form renders it very probable that it grew in tufts from a transversely extended base.

FIG. 84.—ACANTHOGRAPTUS CHAETOPHORUS, NEW SPECIES. HOLOTYPE. (SEE ALSO PL. 3, FIG. 5.)

Horizon and locality.—Niagara dolomite, Hamilton, Ontario.
Holotype.—New York State collection.

ACANTHOGRAPTUS MULTISPINUS Gurley, new species.

The description by Gurley is as follows:

Polypary flabellate-compressed, originating in and sessile upon a black, carbonaceous, discoid base, from which the main branches arise, and then divide and subdivide, run outward, spreading somewhat to both sides and being somewhat undulate; 0.3–0.4 mm. wide; set about 25–30 in 25 mm. of width; their sides beset with processes of variable length and closeness. These processes are in character intermediate between those of *A. walkeri* and those of *A. pulcher*, being stouter, more rigid, and more distant than in the latter species, but less stout, less rigid, and closer together than in *A. walkeri*. Their lengths and closeness are too variable to be well reduced to measurements.

FIGS. 85, 86.—ACANTHOGRAPTUS MULTISPINUS, NEW SPECIES. TWO TYPE-SPECIMENS. (FIG. 85 BY R. S. BASSLER.)

The present species most nearly resembles *A. pulcher*, but in general has the branches more divergent, and with less tendency to parallelism; the fringing processes are stouter, more rigid, and more distinct, and the resulting appearance is less finely feathery.

Horizon and locality.—Niagara chert, Hamilton, Ontario.
Cotypes.—Cat. No. 55309, U.S.N.M., and New York State collection.

Genus THAMNOGRAPTUS Hall.

Thamnograptus Hall, Rep. Progr. Geol. Surv. Canada for 1857, 1858, p. 143, *nomen nudum;* Nat. Hist. New York, Pal., III, 1859, 1861, p. 519; 13th Rep. New York State Cab. Nat. Hist., 1860, p. 62; Can. Org. Rem., Decade 2, 1865, p. 141; 20th Rep. New York State Cab. Nat. Hist., 1868, p. 218 (rev. ed., 1868 [1870], p. 251).—Nicholson, Mon. Brit. Graptolitidæ, 1872, p. 130; Ann. and Mag. Nat. Hist. (4), XVI, 1875, p. 270.—Zittel, Handbuch d. Pal., I, 1879, p. 290.—Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 563, 589; Bull. Mus. Univ. State Missouri, I, 1884, p. 39.—Miller, North Amer. Geol. and Pal., 1889, p. 207.—Počta, Syst. Sil. Centre Boheme, VIII, Pt. 1, 1894, p. 165.—Elles and Wood, Mon. Brit. Graptolites, Pal. Soc., 1903, p. xli.—Ruedemann, New York State Mus., Mem. 11, 1908, p. 204.

This peculiar genus was founded upon two Ordovician species of graptolites, which have recently been studied by Ruedemann. The absence of thecæ or apertures upon the branches has always kept the genus doubtful, and the following descriptions of the Niagaran forms can not be said to add anything to the knowledge of the genus.

The original diagnosis is:

Bodies consisting of straight or flexuous stipes (simple or conjoined at base?) with alternating and widely diverging branches; branches long, simple or ramose, in the same manner as the stipe. Substance fibrous or striate; the main stipe and branches marked by a longitudinal central depressed line, indicating the axis. Cellules or serratures unknown.'

Genotype.—Thamnograptus typus Hall (=*Thamnograptus capillaris* Emmons). Normanskill shale, Kenwood, near Albany, New York.

THAMNOGRAPTUS BARTONENSIS Spencer.

Thamnograpsus bartonensis Spencer, Canadian Nat., VIII, 1878, pp. 458, 462.
Thamnograptus bartonensis Spencer, Trans. Acad. Sci. St. Louis, IV, 1884, pp. 565, 589, 590, pl. 6, figs. 4, 5; Bull. Mus. Univ. State Missouri, I, 1884, pp. 15, 39, 40, pl. 6, figs. 4; 5.—Gurley, Journ. Geol., IV, 1896, pp. 101, 309.

The original description follows:

Stipes single and broad with lineal undulating branches alternately arranged on opposite sides and having half the thickness of the stipe, which is as much as one-sixteenth of an inch broad. The branches which are given off are usually at right angles with the stipe; and are generally half an inch apart; there being an undulation of considerable length opposite to their place of attachment.

Texture corneous and black, the surface being nearly smooth with longitudinal depressions. The branches are usually short and abrupt.

They occur in the Niagara Limestone at Hamilton, Ontario, and the writer has seen them in the rock several inches long.

Quoting from Doctor Gurley's manuscript:

The description of 1884 adds: Branches having half the thickness of the stipe, their bases nearly at right angles with it, but afterwards they bend up-

ward; inserted on the stipe 1 to 2 cm. apart. At point of origin there is usually a depression of considerable length on the side opposite to their place of attachment, and an expansion on the same side. There is a strong medial depression, 0.5 mm. wide (marking a central axis?), extending through the stipe, which is 1.5 mm. broad.

The specimens obtained are not entire. The branches are often widely separated, and are sometimes long and flexuous, extending for several centimeters in length. It sometimes happens that we obtain a long stipe which may be either a portion of the structure below the branches or a portion of a separate branch.

FIG. 87.—THAMNOGRAPTUS BARTONENSIS SPENCER. COPIED FROM SPENCER.

Doctor Gurley further remarks:

Altogether there are 9 specimens which I refer to this species. They vary considerably and tend to arrange themselves in two series, and at different stages in my work I have rated them as separate species and as separate varieties. The latter is still the course I should prefer, if I could with any confidence correlate the two series in any definite way[a] with Spencer's species. But as I can not do so satisfactorily, they are simply characterized as well as possible, and the task of connecting or separating them must remain to be worked out in the light of more complete specimens. I might, however, add that though there is no certainty in the matter I rather incline to believe these two series to represent widely separate fragments of the same polypary.

Series A.

Polypary (?) consisting of long, more or less straight, or flexuous stems, 1.25–2.5 mm., which for long distances are simple and destitute of branches. In the five specimens (on three slabs) plainly referable to this series, only two branches are seen. These branches are about 1 mm. wide, and diverge from the main stem at about 60° or a little less. Texture brown-black, carbonaceous, exactly similar to that of *Inocaulis plumulosa* in the same beds.

FIGS. 88, 89.—THAMNOGRAPTUS BARTONENSIS SPENCER. TWO FRAGMENTS BELONGING TO SERIES B.

Series B.

Main stems and branches much narrower than in series A (stem *ad maximum*, 1.5 mm., usually 0.8, occasionally 0.6 mm. wide; branches mostly 0.5–0.8 mm. wide); branches more numerous, tending to diverge at a right angle or a little less. Texture the same as in series A.

The specimens referred to series A belong to the Spencer collection and are not accessible at present. Those of series B are represented in text figures 88 and 89.

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[a] *E. g.*, both with all of Spencer's species, or either with any definite part thereof. I might perhaps add that a correlation of Series A with Spencer's fig. 4, and of Series B with his fig. 5, seems somewhat plausible.—R. R. Gurley.

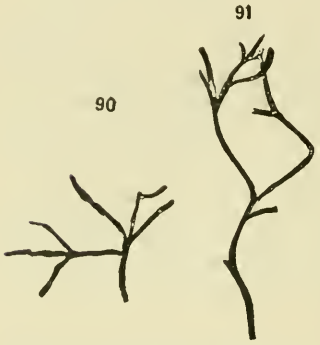
Horizon and locality.—Niagaran (Lockport), Hamilton, Ontario.
Plesiotypes.—Cat. No. 55318, U.S.N.M.

THAMNOGRAPTUS (?) MULTIFORMIS Spencer.

Thamnograptus (?) *multiformis* SPENCER. Canadian Nat., X, 1882, p. 165, *nomen nudum;* Trans. Acad. Sci. St. Louis, IV, 1884, pp. 565, 590, pl. 6, figs. 2, 3; Bull. Mus. Univ. State Missouri, 1, 1884, pp. 15, 40, pl. 6, figs. 2, 3.—GURLEY, Journ. Geol., IV, 1896, p. 101.

The original description is as follows:

Stipes simple, flexuous, and strong, usually divided into two (sometimes three) branches of equal thickness. From both the undivided and divided stipe a few short irregular branches originate at long unequal distances apart; and these may or may not end in two free points. The texture is corneous and black, with the surfaces somewhat striated and impressed with a medial line (indicating a central axis?). In occasional specimens of the same mode of branching, short spinelike processes, from one-half to one millimeter long and half a millimeter apart, probably indicate the position of the cellules on both sides of the branches.



FIGS. 90, 91. — THAMNOGRAPTUS ? MULTIFORMIS SPENCER. COPIES OF SPENCER'S FIGURES.

There is considerable variation in the size of these organisms. The larger specimens are 4 or 5 cm. long, and the stipes are usually about 1 mm. thick; however, some of the specimens, that I have referred here, have not more than half that size. In the larger specimens the branches are usually about half a centimeter apart.

In the rocks of the Niagara formation numerous fragments of organism of the graptolite family occur. Vast numbers, consisting of thick broken stipes, often flexuous, with one or two branches, or those with dichotomous terminations, are found, and can not be referred to any species described. Yet they so closely resemble the better specimens of this species that I have placed them here, although a further study might separate some of them from this species.

Formation and locality.—Fragments of this species occur somewhat abundantly in the Niagara dolomitic rocks at Hamilton, Ontario.

Of this species Doctor Gurley says:

After many endeavors to recognize this species I have failed to find anything which I could confidently refer to it. As far as my experience goes nothing which has any definite structure resembles it. The only things which seem to approximate it are the most fragmentary specimens, too indefinite to be referred anywhere else. A perusal of Spencer's description also leads me to suspect (but I do not assert it) that this species is not much more than a dumping ground for fragments. Certain it is that from time to time series after series of fragments (and at this horizon fragments are unusually and disproportionately numerous) otherwise unplaced were identified as this species, but eventually all except the worst were successfully referred elsewhere. This species must then stand on Spencer's diagnosis and figure.

DESCRIPTIONS OF PLATES.

Unless otherwise stated, the views shown on these plates were prepared by R. S Bassler.]

Explanation of Plate 1.

Page.

Figs. 1, 2. *Dendrograptus? problematicus* Spencer 10
(See also text fig. 6.)

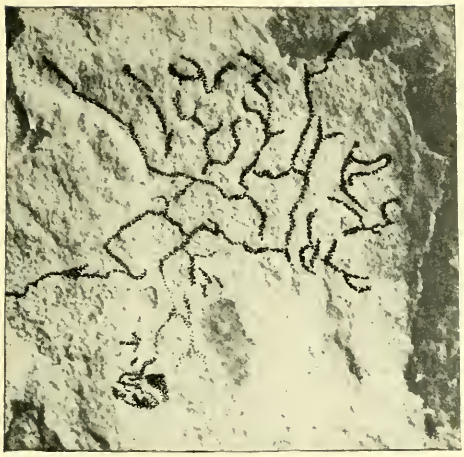
1. A small rhabdosome, × 1.5, arising from a discoidal body.
2. A larger example, × 1.5, showing the lax arrangement of the branches.
3. *Dendrograptus ramosus* Spencer 8
(See also text figs. 3 and 9.)

Gurley's photograph of the specimen, × 1.5, illustrated on page 7.

4. *Dendrograptus ontariocnsis*, new species 12
(See also text fig. 12,)

The type-specimen, × 2.

1



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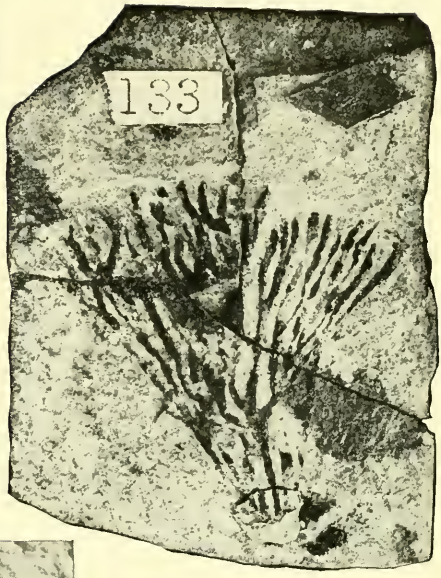

2

4

NIAGARAN GRAPTOLITES.

Explanation of Plate 2.

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Fig. 1. *Acanthograptus granti* Spencer 56
(See also Pl. 3, fig. 4, and text figs. 72–74.)
Gurley's photograph of a specimen, × 1.5, with the rhabdosome drawn in black.

2. *Dendrograptus phainotheca,* new species 11
(See also text fig. 11.)
A retouched photograph of the type-specimen, × 3.

3. *Dendrograptus praegracilis* Spencer 9
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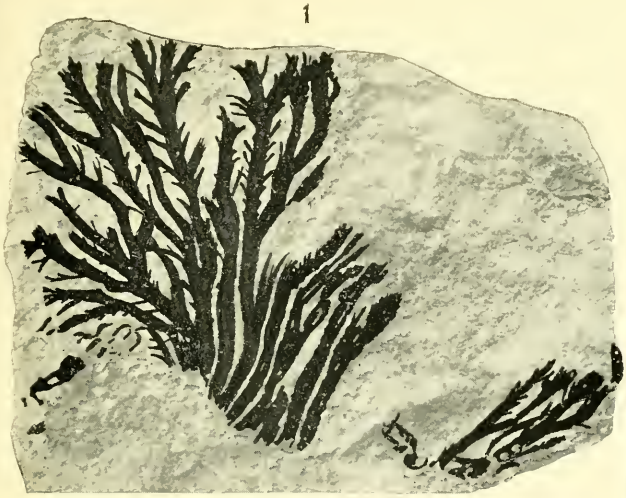
Photograph of the specimen illustrated in text fig. 10.

4. *Dictyonema tenellum* Spencer 28
(See also text figs. 32 and 33.)
A small portion of a rhabdosome, × 2.

5. *Inocaulis ? thallosus,* new species 55
The type-specimen, × 1.5.

6. *Inocaulis ? strictus,* new species 54
(See also text fig. 71.)
Photograph of the type-specimen, × 1.5, by Gurley.

1



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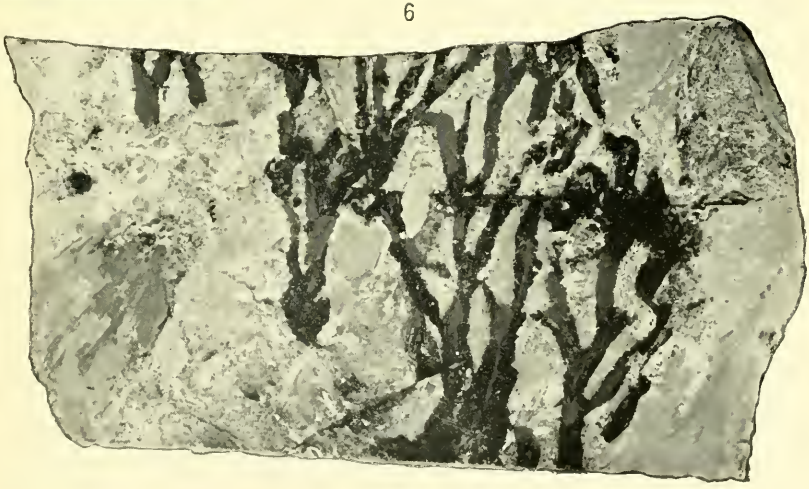

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Fig. 1. *Dictyonema crassibasale*, new species 19
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2. *Dictyonema stenactinotum*, new species 30
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View of the specimen, × 1.5, illustrated in text fig. 35.

3. *Callograptus strictus*, new species 15
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The type-specimen, × 2.

4. *Acanthograptus granti* Spencer 56
(See also Pl. 2, fig. 1, and text figs. 72–74.)
Photograph by Gurley, with rhabdosome retouched in black.

5. *Acanthograptus chaetophorus*, new species 61
(See also text fig. 84.)
Photograph of the type specimen, × 1.5.

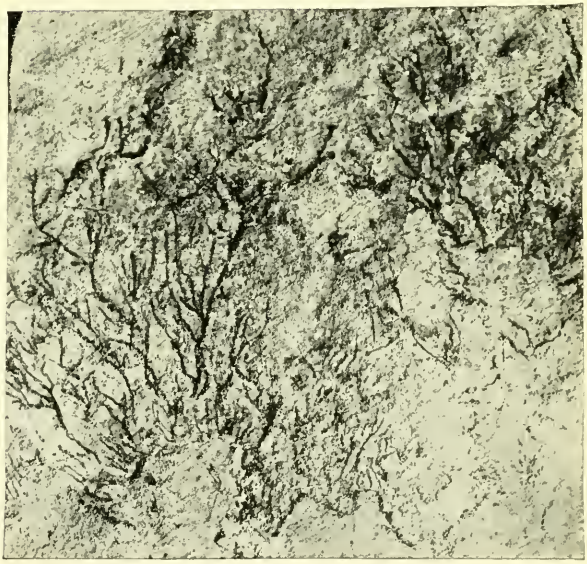
1

3

2

4

5



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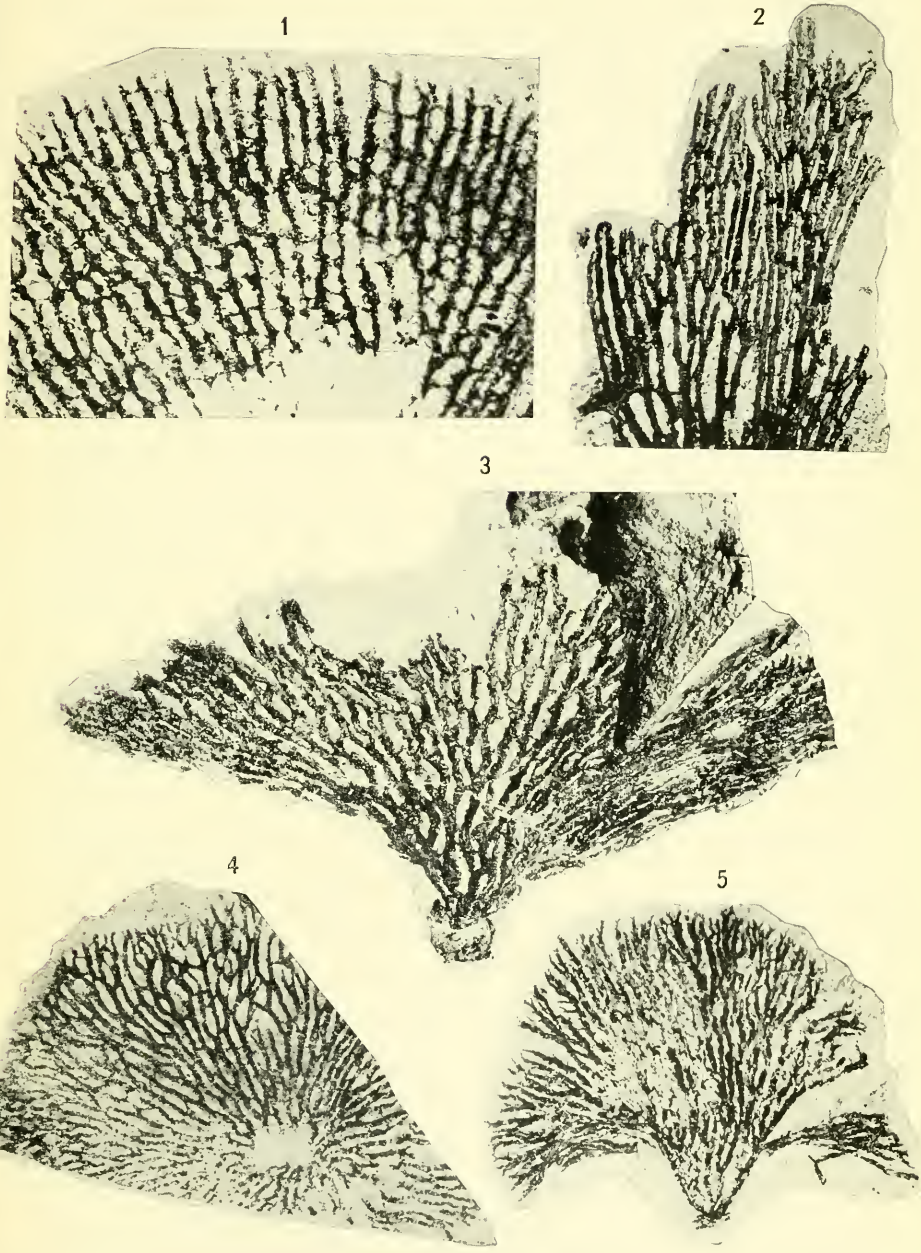

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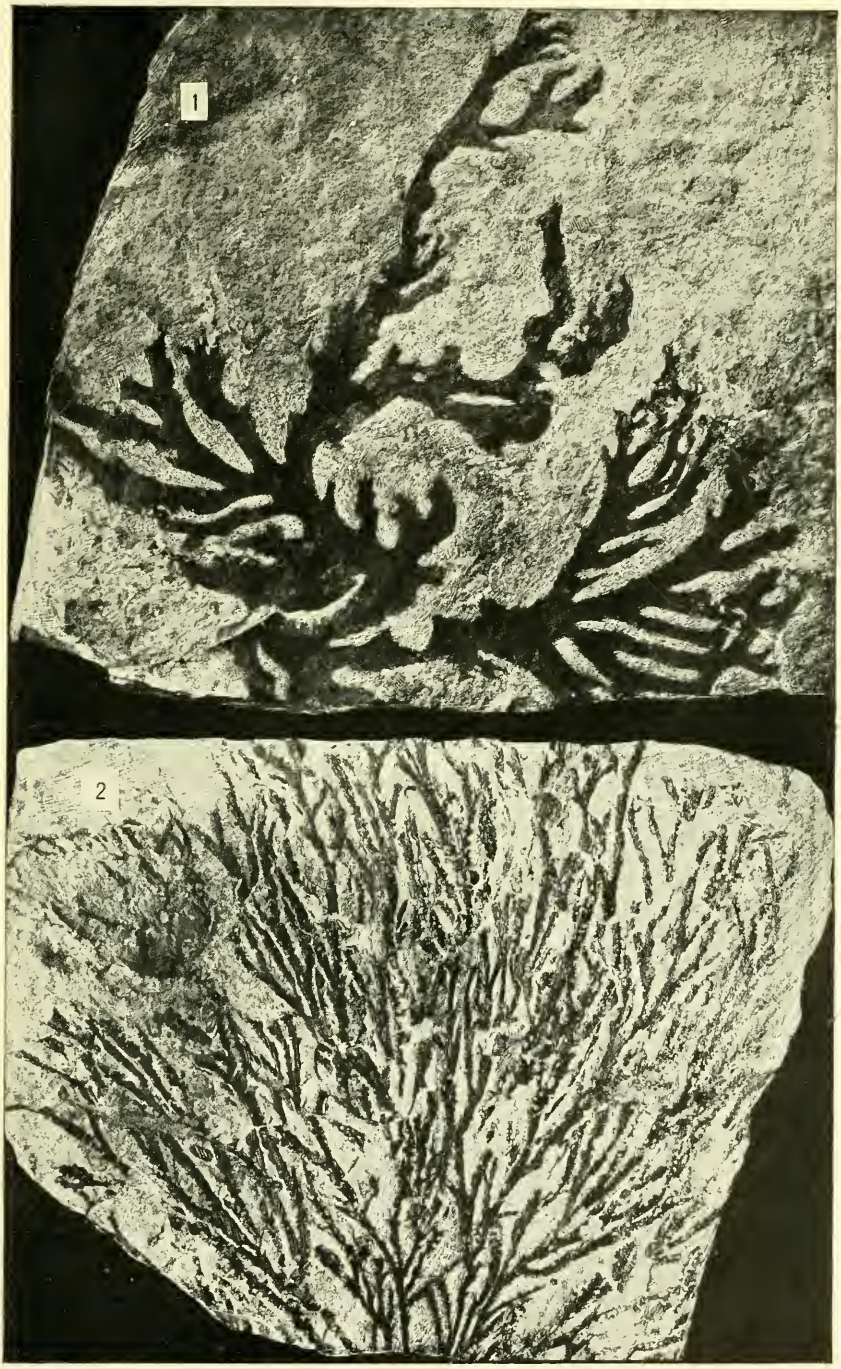

NIAGARAN GRAPTOLITES.

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